Institute of Plant Industry,

INDORE,

Central India.

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PROGRESS REPORT

for the Year Ending 30th June 1935.

EXAMINER PRESS, BOMBAY.

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PROGRESS REPORT

for the Year Ending 30th June 1935.

The Institute of Plant Industry is a Society registered under the Holkar State Societies Registration Act and its primary objects are :—

(a) The investigation of all matters relating to the production and improvement of raw cotton in India.

(b) The agricultural development of the Indian States which are members of the Society.

(c) The training of officers and cultivators nominated by such States.

(d) The training of advanced students nominated by the Indian Central Cotton Committee.

Its funds are derived entirely from subscriptions. In the financial year 1934-35 the Indian Central Cotton Committee made a grant of Rs. 1,15,000 and the member-States in Central India and Rajputana subscribed Rs. 61,950.

The Institute is subsidised by the Indian Central Cotton Committee primarily in order that it may act as a central research station for the elucidation of botanical and agronomic problems of cotton of too wide a nature to be attacked by *ad hoc* schemes. The Indian Central Cotton Committee has also a secondary interest in the Institute in its work for the improvement of variety and cultivation conditions of cotton in Central India and Rajputana.

The interests of the member-States lie in the investigation of the specific crop problems of their own territory, and in the development and dissemination of better seeds and more efficient agricultural practices.

The interests of the Indian Central Cotton Committee and of the member States are complementary, and provide a very satisfactory balance to the work of the Institute.

The Governing Body of the Institute is representative of the Cotton Committee and the member-States, and its President is the Agent to the Governor-General in Central India, *ex-officio*. The Director of the Institute is also Agricultural Adviser to States in Central India and Rajputana, and in addition represents all those States upon the Indian Central Cotton Committee.

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INSTITUTE OF PLANT INDUSTRY, INDORE, CENTRAL INDIA.

PROGRESS REPORT FOR THE YEAR ENDING JUNE 30TH, 1935.

ADMINISTRATION AND GENERAL.

1. General and Board of Governors' Meetings.—

A General Meeting of Members of the Society was held on December 22nd, 1934 when the constitution was amended so as to make the representation of contributors on the Board of Governors proportionate to the amount paid annually. The Board met on October 6th, and on December 23rd when the report for the year ending June 30th, 1934, and the programme for the year 1935-6 were discussed and approved. The Board also sanctioned leave and deputation for Mr. J. B. Hutchinson, Geneticist and Botanist, to allow him to attend the Sixth International Botanical Congress at Amsterdam in September 1935. The Congress having complimented him by their invitation to read a paper in the genetics section, it was felt desirable to enable him also to take advantage of the opportunity of discussion with other geneticists.

2. Contributing Members of the Institute.—

During the year the State of Jhabua in Central India and the Thikana of Khetri in Jaipur became members. One State, Jhalawar, has temporarily withdrawn from membership for financial reasons.

At the closing date of this report the following twenty-three States and Thikanas were members of the Institute, arranged in order of joining:

Indore	Tonk	Orchha
Dhar	Bijawar	Bharatpur
Jaora	Barwani	Jodhpur
Datia	Bikaner	Alwar
Rutlam	Rewa	Khetri
Dewas (Senior Branch)	Jaipur	Bagli
Sitamau	Bundi	Jhabua
Narsingarh	Partabgarh	

The financial situation having become somewhat easier in most States and the Institute's reputation having grown, it is satisfactory to record rather numerous enquiries from States which are not yet members.

On the other hand the Indian Central Cotton Committee, faced with the exhaustion of its accumulated reserves has found itself unable to continue to sanction annual grants of Rs. 1,15,000 and the Institute's annual income from this source will now be reduced by Rs. 15,000. This serious situation can only be met by further contributions from States or by the dismissal of personnel which will reduce the output of research work.

3. Staff and Students.—

The Director was absent on leave from March 10th, 1934 to October 18th, 1934 and the Geneticist and Botanist officiated during that period.

The post of Senior Botanical Assistant was filled, after advertising it, by the promotion of Mr. R. L. M. Ghose, M.Sc., who had been Botanical Assistant for some years.

For lack of funds a number of sanctioned posts cannot be filled.

Mr. G. G. Phadke, L.Ag., Junior Farm Assistant remained on deputation as Agricultural Officer to Bharatpur State.

It is a pleasure to record the keenness and enthusiasm of personnel in all Sections.

4. Visitors.—

On the 26th July, 1934 the Institute was honoured by the visit of Their Excellencies Sir George and Lady Beatrix Stanley. Viceroy and Vicereine, who spent an hour examining in detail some of the more important of the Institute's achievements and the work in progress.

Among other visitors were the following:—

Amar Singh, Kunwar of Jasol, Director of Agriculture and Grass Farms, Jodhpur State.

Anderson, Jane, (Miss) Mission Hospital, Indore.

Ardeshir, Major, D. K., M.R.C.S., Mhow, C.I.

Armstrong, Dr. Allan E., Secretary, United Church of Canada Mission, Toronto, Canada.

Augier, D. E., O.B.E., Joint Opium Officer, Malwa States and Assistant Opium Agent, Neemuch, C.I.,

Basu, S., Meteorologist, Poona.

Ben, Mira (Miss) Wardha,

Bhandari, K. L., Rai Bahadur, Managing Director, Nandlal Bhandari Mills, Indore.

Brée, P. G., I.C.S., Excise & Opium Commissioner in Central India and Adviser on Opium Affairs in Rajputana, Indore.

Burnett, Major, R. R., Chief Adviser, Tonk State, Rajputana.

Caswell, K. (Miss), Mission Girls' High School, Indore.

Chatterjee, Rev. J. C. Superintendent of Education, Delhi, Ajmer-Merwara and Central India.

Crofton, R. M., I.C.S., Excise & Opium Commissioner in Central India and Adviser on Opium Affairs in Rajputana, Indore.

Davies, P., Consulting Engineer, Holkar State.

Desai Mahadev, Maganwadi, Wardha.

Devisingh, Thakur Lt. Col., Rai Bahadur, Sigha Member, Jaipur.

Dhanda, Captain, H. C., Deputy Commissioner, Commerce and Industry, Holkar State, Indore.

Dodds J. L., (Mr. & Mrs.) American Presbyterian Mission, Dehra Dun, U. P.

Fatehuddin, Chowdhri Khan Bahadur, Offg. Director of Agriculture, Punjab, Lahore.

Foster, A. R., Imperial Chemical Industries (India) Ltd., Calcutta.

Gandhi, M. K., Wardha.

Ghosh, Harijiban, M.A., Professor and Head of the Department of English, Holkar College, Indore.

Gulam Ali, Huzur Secretary to His Highness the Nawab of Jaora, C.I.

Hardy, M.E., D.Sc., Private Secretary to His Highness the Maharaja Holkar.

Hill, M. (Miss), Toronto, Canada.

Hilliard, D. (Miss), Mission Hospital, Indore.

Holkar, Malhar Rao, Sardar, Ada Bazar, Indore.

Holkar, Her Highness the Maharani, Indore.

Hutchinson E., (Miss), Pemba, Zanzibar.

Kale, Dinkarrao, Sardar, Dewas (Senior).

Kanungo, Musahib-i-Khas Bahadur, S. V., M.A., Finance Minister, Holkar State, Indore.

Karmarkar, D. V., M.Sc., Ph. D., A.I.I.Sc., Cold Storage Research Scheme, Kirkee, Poona.

Khan, Sarfaraz Ali, Khan Bahadur, Chief Secretary, Jaora, C.I.

Khasgiwala, Fatehlal, Agricultural & Treasury Officer, Partabgarh (Rajputana).

Kirpelani, Capt. J. K., I.M.S. (Retd.) Indore.

Kothare, Rao Bahadur, G. R., M.L.C., Member, Indian Central Cotton Committee, Khamgaon, Berar.

Lalbhai, Seth Kasturbhai, Ahmedabad.

Langar, Pandit, M. M., Diwan, Jhalawar State, Rajputana.

Macnabbb, Lieut.-Colonel R. J., I.A., Agent to the Governor-General in Central India, Indore.

Mahendra Singh, Thakur, Revenue Member, State Council, Bundi, Rajputana.

Masih, Kenneth, B.V., Christian College, Indore.

Mehta, Chunilal B., Member, Indian Central Cotton Committee, Bombay.

Mukerjee, R. K., Professor and Head of the Department of Economics and Sociology, University of Lucknow, U. P.

Mukerjee, W., Allahabad Agricultural Institute, Naini.

Myers, A. J. W., Hartford, Connecticut (U.S.A.)

Nadkar, Dewan Bahadur, K., Dewan and President, State Council, Dhar, C.I.

Naik, Bhimbhai, Sardar, Rao Bahadur, R., M.L.A., Member, Indian Central Cotton Committee, Surat.

Narsingarh, His Highness the Maharaja of,

Natu, R. S., B.S.E., Divisional Engineer, Yeshwant Sagar Works, Indore.

Orchha, His Highness the Maharaja of,

Parekh, Manilal, Rajkot, Kathiawar.

Patterson G. (Miss), United Church of Canada Mission, Kharua, C.I.

Patwardhan, K.A ., M.Sc., Master, Daly College, Indore.

Pearce, F. G., Principal, The Scindia School, Gwalior.

Pearson, D. (Miss), Mission Girls' High School, Indore.

Prabhunath Singh, Maharaj, Narsingarh, C.I.

Prayag, Rai Sahib C. H., Cotton Breeder, Jalgaon.

Rajkumar Singh, Managing Director, Rajkumar Mills, Indore, C.I.

Rama Reddi, P. H., M.A., B.Sc., I.A.S., Secretary, Indian Central Cotton Committee, Bombay.

Ram Prasad Singh, Rai Sahib, Thakur, Economic Botanist, United Provinces Government, Cawnpore.

Rennick E. deC. (Miss), Companion to Her Highness the Maharani, Rewa, C.I.

Reshimwale, Gopal Rao, Sardar, Indore.

Roberts, Sir James R., Special Member, Council of State, Dewas Senior C.I.

Roberts, Lady, Dewas Senior, C.I.

Sardar Kurgain H.A., M.A., I.E.S. (Retd.), Late Inspector of Schools, Nerbudda Circle, C.P., and Southern Division, Bombay.

Sajjan Singh, Narsingarh, C.I.

Sangli, M. G., Jodhpur.

Sangli, S. G. c/o Sangli Bros., Indore, C.I.

Scott, Rev. A. A., Principal, Christian College, Indore.

Schneider, B. H., Dr. (with a party of 25 students), Allahabad Agricultural Institute, Naini.

Short, H. C., Commissioner in India, Lancashire Indian Cotton Committee.

Sully, T. D., Principal, St. John's College, Agra.

Talcherkar, V. A., Late Textile Expert to the Holkar Government, Indore.

Taore, K.A., Dr., Dewas (Senior), C.I.

Taylor, Rev. J. T., United Church of Canada Mission, Indore.

Taylor, Rev. H. E., United Church of Canada Mission, Indore.

Thakurdas, Sir Purshottamdas, Vice-President, Indian Central Cotton Committee, Bombay.

Trench, C. G. Chenevix, C.I.E., I.C.S. (Retd), Revenue Commissioner, Udaipur, Mewar.

Vijayaraghavacharya Dewan Bahadur Sir T., K. B. E., Vice-President, Imperial Council of Agricultural Research, Delhi, President, Indian Central Cotton Committee.

Wither, C. (Miss), Mission Hospital, Indore.

Zalim Singh, Sardar, Kamavisdar, Dewas (Senior,) C.I.

Zutshi, Dewan Bahadur, B. N., Vice-President, State Council, Rewa, C.I.

5. Library.—

Accessions during the year were thus :—

Text-books and works of reference	..		..	71
Volumes of Journals	..	..	..	193
Reports, Bulletins, etc.	..	..	..	546
		Total accessions	..	810

Six new Journals have been added to the list of periodical taken by the Library. Loans of 182 books and journals were made to cotton research workers and others and to libraries in India and abroad, a routine of circulation being in force. No less than 1690 books and bulletins have been sold, to the value of nearly Rs. 750. Progress has been made with the classification of the library by the Universal Classification System ; the books and pamphlets have been re-arranged on the shelves and a shelf index made for the latter.

RESEARCH WORK.

6. Organization.

There is little new to record under this heading ; the extra facilities provided mentioned in the last report have been fully utilized with increased output of work and efficiency. A still larger number of field trials have been handed over to the Farm Section for execution so freeing research staff for other work.

The methods referred to in the 1934 report of central control of field experiments in out-stations have proved themselves and have been expanded ; by their aid a very large mass of information of known accuracy has been acquired.

Once again the cordial co-operation of the States' Darbars and their officers, as well as no small number of voluntary workers, must be acknowledged. With this aid much more rapid progress is made possible.

Similar acknowledgment is also due to the Provincial Departments of Agriculture, notably those of Bombay, the United Provinces, the Central Provinces, the Punjab and Madras for much assistance and co-operation willingly rendered, also to Agricultural Departments in the United States of America, Australia, South Africa and other parts of the Empire and to officers of the Empire Cotton Growing Association.

7. Weather and its effect on crops.

In Malwa, following a *rabi* season of low rainfall, the 1934 monsoon was exceptionally heavy, a total of no less than 57.37 inches of rain being recorded, the yearly average being about 30 inches. Thus for the fourth

successive year *Kharif* crops on the black soils and also in East Centra India suffered from the deterioration of soil through excess of moisture. Fortunately there were two breaks in the continuity of rainfall which enabled some recovery to be made. In the Nimar tract south of the Vindhyas excellent crops were the rule and Rajputana with its lighter soils on the whole gained by the higher rainfall it experienced, although on the Eastern side late rains also did damage, particularly to cotton and small grain crops.

Severe frosts in mid-January caused much damage in all parts of Central India and Rajputana. The third pickings of cotton were usually destroyed and in some areas even the second; this has given a set-back to the improved Malvi cotton distribution schemes. Gram suffered badly, sugar cane was damaged, especially for use as seed, and tobacco in the early districts was cut to the ground and abandoned. Severe hailstorms harmed *rabi* crops in East Central India.

8. Cotton—Botany and Genetics.

(a) Botanical Survey of cottons in Malwa and Nimar.

A draft paper on the *botanical classifications of cotton* with special reference to Asiatic species has been written and awaits the verification of a few small points at the Herbarium, Royal Botanical Gardens, Kew. This paper deals with botanical principles only.

The analysis of the *survey of Malvi and Nimari cottons* is at present being written up. It is hoped in this paper to indicate the possibilities and limitations of an agricultural classification.

The survey data reveal very interesting and important differences in survival value of different types in Malwa and Nimar, and physiological work is being undertaken to discover the causes of the differences in plant response. The position of Upland types in the Malvi crop also appears to be anomalous, and experiments have been laid out to discover whether it can hold its own against *desi*, and if so, by what means.

Useful information has been obtained and valuable types have been selected from a collection of Burma and Assam types obtained through the good offices of the Hon'ble the Agent to the Governor-General in Central India.

(b) Genetics.

The study of X-rayed material yielded negative results. Some indications of cytological abnormality were noted but on further investigation they proved to be of small importance. This line of work has been suspended in favour of lines of more immediate value.

Work on the inheritance of major factors continues, and results are expected in the coming crop. Certain lines of study which on investi-

gation proved likely to yield a small return for a large amount of work have been abandoned in favour of more promising subjects. The more important changes involved are the closing down of studies on minor lint-colour factors and the exclusion of the study of aberrant mendelian ratios from the short-petal experiments.

Work on the *inheritance of quantitative characters* has now become the main part of the genetics programme. The results obtained by the improved technique (see below under Statistics) developed in the season under review have been very encouraging indeed, and indicate that modern statistical principles are capable of providing a solution to what has been in the past one of the chief difficulties in the study of quantitative inheritance, namely the control of environmental variation. Work is proceeding in three main lines :

(i) The study of genetic variance in relatively uniform material. This has led to the discovery that considerable further improvement is possible in both Malvi 1 and Malvi 9, and also that Malvi 9, which is the better of the two, is also the one which is capable of the greater further improvement. Variation between strains in susceptibility to wilt has been observed in Malvi 9 and has provided an opportunity of studying the inheritance of this character.

(ii) The study of genetic variance in crosses between three important agricultural types of *G. arboreum*, (Malvi, Bani, and Roseum). It is intended in these crosses to study particularly the relation between characters of commercial importance and those responsible for the morphological differences between the types. Some information is already available concerning the extent to which the lint characters of one type may be combined with the morphological characters of another, and it is hoped to extend and amplify it. This work links up naturally with the study of the survival value of different morphological types, and will have an important practical application in delimiting the breeding potentialities of the commonly cultivated types of *G. arboreum*, and in serving as a guide to plant breeders faced with the problem of combining the greatest possible vigour with the most desirable lint characters.

(iii) The study of genetic variance in interspecific crosses. Work on this subject was started in 1933, and F_2s and back-crosses will be grown in the coming season. The programme has been enlarged and intensified in response to the need of plant breeders for information on this very obscure subject.

Study of the rate of mutation in mutable strains is proceeding slowly, as mutable strains do not grow well in black soil. The occurrence of

somatic mutation from brown to white lint (KK to kk) has, however, been demonstrated in heterozygous material.

(c) Cytology.

Cytological work has demonstrated that in one of the two sterile mutant strains, sterility is not due to cyto-genetic abnormality. The inheritance of sterility in this type remains obscure. The other strain has been shown to carry a simple mendelian recessive factor for sterility. The cytology of the sterility in the mendelian recessive is now being studied.

The study of hybrids between *G. africanum* (=*G. anomalum*) and cultivated Asiatic cottons continues, and second back-cross seedlings are now being raised. It appears that the normal chromoscome complement of all plants so far studied is 26, but certain plants contain small "islands" of tetraploid tissue.

(d) Physiology.

The study of hair characteristics has been slowed down pending receipt of the new tester designed by Dr. Nazir Ahmad, Director of the Technological Laboratory, Matunga, Bombay. The study of tests for lint quality to deal with large numbers of small samples is proceeding. The spinning value of Malvi cottons predicted from fibre tests appears to be almost 50per cent higher than the actual value as determined by spinning tests.

(e) Selection and Breeding.

The amount of seed of Malvi 1 and Malvi 9 available for distribution for 1935 *Kharif* was curtailed by the frost which destroyed the crop in the middle of January 1935. The demand for seed has been most encouraging, and far beyond the supply available. Both Malvi 1 and Malvi 9 have been distributed, and owing to the discovery that the two strains probably differ in their response to different soils and regions, both are being retained in the distribution scheme for the present.

A number of new selections from Malwa will be tested in replicated progeny rows this season, and desirable progenies will be carried on and tested against the existing strains.

Selection work on Mâlwa Upland cotton has been transferred to Badnawar (Dhar State) in the best Upland cotton growing district in Malwa.

At Dhar, progeny-row selection has been initiated in a mass-selected Malvi cotton maintained by the Agricultural Department, and in the local Nimari bulk has given an immediate improvement of considerable magnitude.

Thanks to the co-operation of the Agricultural Department, Dhar State, it has been possible to carry out the breeding work in all three of these centres by the replicated-progeny-row technique developed at the Institute.

Work is being started on the much-needed improvement of Rajputana Bengals. Hybrid material from a cross made in Trinidad has been sent for study in Ganganagar (North Bikaner), and a beginning has been made in the separation of longer-linted components from the *desi* mixture of Jodhpur and Jaipur.

(f) Variety Trials.

A large number of variety trials were carried out in the period under review. The potentialities of existing selected varieties for the different tracts of Central India and Rajputana are now fairly well known, and may be summarised as follows :

1) Black soil tracts of Central India (Malvi plateau) :

(a) Malvi 1 and Malvi 9 yield about 20 percent more than the local mixture. Malvi 9 gins 32-34 percent as against about 28 percent, in local. Malvi 9 spins about 40 percent higher counts than local.

(b) Cambodia yields very much less than *desi* on all types of land with the possible exception of areas irrigated from tanks, which are being further investigated. It may be said with confidence that Cambodia will not pay the cultivator in Malwa unless he receives a 50 percent premium for his *kapas*. The actual premiump aid for Cambodia *kapas*, as ascertained from ginners and the Indore Mills, is not more than 15 percent.

(2) Nimar tract :—Banilla will give the cultivator an immediate increase in return on account of its higher ginning percentage. Verum is lower yielding than the local mixture, but would pay if pooling and marketing facilities were provided.

(3) Gang Canal Colony, well-and tank-irrigated sandy lands in Rajputana :—

Cawnpore 520 is a definite improvement on Mollisoni in the Gang Canal Colony, and will probably pay better than local on most irrigated sandy lands. Rosea Bhatla has given very high yields in Rajputana, but is very poor in quality. It is rather doubtful whether American types have any permanent place in Rajputana.

(4) Bundelkhand : The extension of cotton in this tract would be of very doubtful value. Yields in all trials carried out for the Institute have been extremely low owing to heavy boll-shedding after untimely rains, and pink bollworm attack. No recommendation can be made.

9. Cotton—Physiology, Pathology and Agronomy.

A very large amount of data of varied character has been accumulated and is being reviewed. The following summary deals with only a small fraction of it.

(a) Biochemical studies on Wilt.—

Indications from the previous year's work were confirmed, thus :—

(i) *Root relationships.* In the course of root studies healthy and wilted plants were removed from the soil together with the whole of their root systems. Microscopic examination of this material is being made to trace the course of infection. This work is not finished but it has been amply confirmed that the presence of fungus in a plant does not necessarily lead to its death, or even to any wilting. On the other hand wilting followed by death occurred when no fungus could be found.

Further examination of the root systems of pairs of healthy and wilted plants again showed less root activity in diseased plants than in healthy ones. A more detailed examination is being made, some of the results of which are tabulated.

TABLE 1.

Root Activity of Healthy and Wilted Cotton Plants in Relation to Soil Zones.
1933-34

Average lengths in inches of active roots of Malvi Cotton.

(Based on root exposures of 21 plants)

Soil zones.	Healthy	Wilted.	P.
0″-9″	37.1	15.3	<0.01
9″-18″	17.4	5.3	<0.05 >0.02
18″-downwards	16.6	8.9	>0.05

Note :—In this and subsequent tables when P is shown as less than 0.05 the odds in favour of the validity of the result shown are 20 to 1; if less than 0.01 the odds are 100 to 1. When P is greater than 0.05 the odds are less than 20 to 1.

It seems that this weakening of root activity is located in the upper oil zones and it is from them that the plant's nutrition is chiefly derived. It appears that this is a concomitant of wilt.

(ii) Last year's observations on the *periodicity of virulence* were further extended and amplified. Periodicity in virulence is now established. This data is being examined in greater detail.

(iii) *Soil moisture relations and wilt.*

Total and hygroscopic moistures were determined, at intervals in the field in two zones around the roots of healthy and wilted plants. Results are given in Table 2., A. B. C.

TABLE 2.

Mean percentage moistures in soils around the roots of healthy and wilted Cotton Plants.

A

Total moistures.

Depth of soil	Healthy plants	Wilted plants	Total.
3"-6"	27.65	35.14	62.79
9"-12"	29.21	30.30	59.51
Total ..	56.86	65.44	122.3

Healthy < Wilted $P < 0.05$, Sig. diff. 7.21

B

Hygroscopic moisture.

3"—6"	9.7	12.9	22.6
9"—12"	11.6	10.8	22.4
Total	21.3	23.7	45.0

Interaction of depth with healthy and wilted plants.—
Moisture values. $P < 0.05$, Sig. diff. 2.72

C.

Ratios of mean percentage moistures for two depths around the roots of healthy and wilted cotton plants.

Ratio	Healthy plants.	Wilted plants.	P.	Significant difference.
$\frac{9''-12''}{3''-6''}$	1.05	0.90	<0.05	0.14

The moisture contents around wilted plants were higher than around healthy plants, (A). Ratios of moisture contents in the lower zones to those in the higher zones were greater than unity and higher for healthy plants than for wilted plants, for which the ratios were less than unity (C).

The hygroscopic moistures of the upper soil zones were higher around wilted plants than healthy ones (B).

The physical condition of soil around healthy plants seems to permit a greater percolation of water to lower depths, and conversely the upper zones around wilted plants are charged with larger amounts of water, because the soil has become less permeable (as indicated by the higher hygroscopic moisture of those zones). The influence of this on root aeration is clear. The reduced activity actually found in the upper portions of the root systems of wilted plants mentioned above, corroborates these observations.

Leaf samples from healthy and wilted plants were collected and are awaiting analysis, to locate the changes in the metabolism of the plants brought about by reduced root activity.

(iv) *Nutrition and cotton wilt* :—

Another line of investigation started in 1933 was as follows :—

Soils, both in pots (1933 &'34) and in the field (1934), were treated with inorganic nutrients in different proportions, manures of widely different compositions and properties and dressings of substances calculated to effect a physical improvement of the soil.

The soils were inoculated with vigorous cultures of the fungus and sown with Malvi cotton. Repeated inoculations were made to ensure active infection throughout the period of observations. The identical

soils in pots of the 1933 experiments were given the same treatments in 1934.

Different degrees of virulence were observed in different treatments in fields and pot cultures. Some of the results are given below. (Table 3, page 15).

In the series with added nutrients, the same relative differences were observed successively for two years. Some treatments have increased and others have decreased the virulence. In 1933 the highest virulence was induced by nitrogen alone, and with phosphate ; it increased considerably in 1934. Potash with phosphate (1 : 1) in 1933 did not increase virulence significantly but in 1934 this treatment reached the level, in this respect, of the nitrogen alone and with phosphate.

When the ratio of potash and phosphate was altered in either direction the increase of virulence in 1934 did not reach significance, though reduction in potash nearly did so.

Neither Magnesia nor lime differed from control in 1933 but gave a significant rise in virulence in 1934 of the same order as did potash and phosphate ($\frac{1}{2}$: 1).

Compost and glue in both years showed no significant difference from farm yard manure and control, though the first pair showed a numerical rise in virulence in 1934 and the second pair a fall.

An excessive supply of nitrogen seems to be very powerful in increasing susceptibil'ty. A study of the cumulative effect of several treatments is perhaps likely to give further information as to the nature of the balance between soil components which determines resistance or susceptibility.

(v) *The yield of cotton as influenced by wilt incidence.*

In order to discover whether, in an infected soil, an invisible attack on apparently healthy plants could be traced from a measure of their yield vigour, plant yields of *Kapas* were recorded in 1933 and 1934 for apparently healthy plants growing in apparently wilt-infected and uninfected field patches. These were compared with yields of wilted plants, both dead and showing fresh growth. The average yields per plant are tabulated with a statement of significances of their differences in Table 4. These observations were taken from time to time over the harvest period on plants surviving to the bearing stage. The yield is seriously depressed by wilting, whether the plant dies or survives to grow later. The differences between yields of healthy plants from affected and unaffected patches were not significant, but it is yet to be seen whether they would be significant when compared picking by picking.

TABLE 3.

Effect of nutrients on incidence of Wilt.

	Treatments	1933-34.	1934-35.	Increase in death % in 1934-35 over 1933-34.
1	N. (NH_4NO_3) Ratio, ammoniacal N to nitrate N 1:1	50.0	100.0	+50.0
2	$N + P_2O_5$	50.0	91.7	+41.7
3	$K_2O + P_2O_5$ (1:1)	25.0	80.0	+55.0
4	CaO	16.7	65.2	+48.5
5	$K_2O + P_2O_5$ ($\frac{1}{2}$:1)	8.3	41.6	+33.3
6	$K_2O + P_2O_5$ (1:$\frac{1}{2}$)	8.3	33.3	+25.0
7	MgO	0.0	49.2	+49.2
8	Compost	0.0	29.2	+29.2
9	Glue	0.0	19.2	+19.2
10	Farm Yard Manure	50.0	42.8	— 7.2
11	Control	19.4	12.2	— 7.2
	P.	$<.05$	$<.05$	
	Sig. diff.	27.2	30.8	

Salts used were ammonium nitrate for N, potassium sulphate for K_2O, sodium phosphate for P_2O_5.

TABLE 4.

Influence of Wilt on cotton yield.

Seed cotton, gms. per plant.

Healthy plants.	Mean yield.	Comparison	n.	t.	P.
(A) From unaffected patches.	17.05	A Vs. B.	47	1.7	>.05
(B) From affected patches	12·0	A Vs. C.	45	4.89	<.01
		A Vs. D.	40	4.48	<.01
Wilted plants					
(C) Dead	4·3	B Vs. C.	54	4.7	<.01
		B Vs. D.	49	4.3	<.01
(D) Resumed fresh growth	4.2	C Vs. D.	47	.009	>.05

(b) Cotton nutrition in relation to environment : Yield

(i) Soil type :—The influence of sowing date on yield was reported last year : that of soil type was then investigated in lysimeters filled with field soil, zone by zone, as it exists in nature. The soils used were :

(1) Jaipur sandy soil.

(2) Soil of the Badnawar tank areas in Dhar State (noted for good Cambodia cotton).

(3) Black soil, well-drained but shallow (about 2 to 3 feet), from Institute Field 31.

(4) Light-grey-coloured, deep soil (about 15 feet), well-drained, from Institute Field 40.

In 1933 Cambodia (Indore 1) and Malvi (No. 9) cotton was sown, no manure was given and after the monsoon, rainwater was applied as required; hence the intrinsic differences in productivity and varietal suitability of the soils were the only operating factors. The relative exhaustion of these soils by the cotton crop was measured by growing a second crop of the same varieties in 1934. Again no manure was given nor any water after the cessation of rains which were exceptionally copious.

In this and the next three experiments, which were in the nature of "feelers", the data given in Tables 5 to 9 are not capable of statistical examination.

TABLE 5.

Calculated yields of seed cotton in gms. per 100 sq. ft. in lysimeters.

1933 & 1934.

Variety.	Soil 1		Soil 2		Soil 3		Soil 4	
	1933	1934	1933	1934	1933	1934	1933	1934
Indore 1 ..	289	15	1332	113	110	0	237	7
Malvi 9 ..	449	218	1194	250	212	169	431	232

In 1933, soil 4 yielded more than soil 3 but slightly less than soil 1; soil 2 stands by itself. In general there was a great fall in yield in 1934, much more than was to be expected from seasonal variation. This fall is greater for Cambodia than Malvi which yielded 20%, 46%, 51% and 79% less in soils 3, 4, 1 and 2 respectively. Soil 2 (Badnawar) comes from the seepage areas of tanks and these soils are heavily manured. The Cambodia crop in Jaipur is also heavily manured and then yields almost as well as at Badnawar. The successful cultivation of cotton on the same land year after year practised at Badnawar seems to depend, therefore, on the very heavy manuring given—a custom inherited from the opium-crop practice by its present successor. The deterioration of this soil through one crop of cotton is more serious than that of ordinary black cotton soils and it is questionable how far the current practice is sound.

(ii) **Humus supply:** It was reported in 1934 that yields of Malvi increased when manure was applied to the whole profile, in strong contrast with the insignificant yield differences from field crops surface dressed.

Cotton—Cambodia (Indore 1) and Malvi (No. 9)—was grown in the same manured profile plots in 1934, to ascertain the continuity of the effect of profile application, with the following results :—

TABLE 6.

Calculated yields of seed cotton in gms. per 100 sq. ft. in manured profile plots.

Treatment.	Malvi 9.		Indore 1
	1933	1934	1934
No treatment ..	1170	656	165
Farm Compost ..	2167	1396	749
Farm Yard Manure ..	1886	916	615
Municipal Compost ..	2376	1192	547

In 1933 manures were mixed throughout the profile down to the *murum*—18-24 inches in depth. In 1934 they were given as surface dressings at 10 tons per acre.

Because of a difference in plant spacings the yields for the two years should not be compared together but the order of productive capacity of treatments may be contrasted.

The 1934 manured yields are so much higher than the control that the effect of profile manuring in 1933 can be assumed to have been continued. It is noteworthy that farm compost and municipal compost (with its higher phosphate content) have changed places in 1934 and the superiority of Malvi over Cambodia on black cotton soils, both manured and unmanured, is clearly indicated.

(iii) **Soil texture** : The influence of open surface texture reported last year was tested for residual effect, a cotton crop being sown again on the same plots with the following results.

TABLE 7.

Soil texture and cotton yield—1933 & 1934

Calculated yields of seed cotton in gms. per 100 sq. ft.

Variety	Unmanured.			Manured.		
	Control	Heated soil: 6" surface layer	Heated soil: 50% in 6" surface layer.	Control	Heated soil: 6" surface layer	Heated soil: 50% in 6" surface layer
Year 1933						
Indore 1 ..	221	456	608	277	762	955
Malvi 9 ..	658	1164	801	910	1399	1174
Year 1934						
Indore 1 ..	163	26	123	143	115	68
Malvi 9 ..	215	375	347	232	222	144

In 1933, in unmanured plots, the 50% heated-soil treatment gave the highest yield with Cambodia, and the full six-inch-layer treatment with Malvi. The response to manures for Cambodia was considerably higher in the plots treated with heated soil than in the control. Malvi responded better than Cambodia to manure on untreated plots but when the plots were treated with heated soil the percentage increase of Malvi due to manure was less than that of Cambodia, and also less than its percentage increase in response to manure on untreated soils. But the absolute yields are still highest for the treated plots, the full six-inch-layer (with manure) being the best. This seems to indicate that the very open texture induced by the six-inch-layer of heated soil influences Malvi yields in the same way and to a greater extent than does manuring. With Cambodia, however, open texture was an essential factor for any increase in yield, with or without manures.

All yields fell in 1934, but the fall was least with Cambodia in the untreated plot, without manure. The greatest exhaustion took place in manured plots except for one plot with a six-inch-layer treatment. The degree of exhaustion is not strictly parallel to the yields of 1933 probably because of the varying degree of subsequent recuperation. Manure has partially compensated for the exhaustion of the full six-inch-layer plot. The net yields are, however, highest in controls in 1934.

Malvi also shows a similar exhaustion—more than Cambodia in the control plot—and the differences due to heated soil treatment or manuring are slight. Malvi shows a better response to heated soil treatment without manures than does Cambodia. The greater responses in 1933 of Cambodia to 50% heated soil and of Malvi to the full dressing probably indicate the reaction of their root-systems to the balance maintained between moisture and aeration, due to the treatments in their active zones. The favourable influence of the manured profiles is however the same for both varieties, showing clearly the superiority of humus in raising yields. It is also evident that about six inches depth of soil of open texture brings a higher response to manures.

(iv) **Nutrients.**—

In spite of negative results from field trials in 1931 and 1932, the results set out above clearly indicated the possibility of a favourable response to manures under certain soil conditions. A qualitative test was made in 1933 in pot-cultures to find what nutrients were most likely to induce response. The 92 pots were filled with uniformly graded surface soil treated in bulk with their respective nutrients. The experiment was done in duplicate with Cambodia (Indore 1) and Malvi (No. 9) cotton.

In 1934 another experiment was made with four replications, using 192 pots, to test the effect of the more promising nutrients upon soils treated to bring about differences of texture by flocculation.

The results are shown in Table 8, A to F.

TABLE 8.

Differences in response of Cambodia Indore 1 and Malvi 9 cotton to nutrients.

A. **Maximum response—1933 Expt.**

Influence on	Indore 1			Malvi 9		
	Treatment	Control	Wts. or hts. max.	Treatment	Control	Wts. or hts. max.
Yield of seed cotton.	Am. sulph. in 2 doses	1.2	21.2	Am. sulph.+di-sod. hyd. phosph. in 1 dose.	2.6	19.3
Plant weight after 43 days.	Am. sulph. + di-sod. hyd. phosph.+pot. sulph. 1 dose	2.7	13.0	Am. sulph. + di-sod. hyd. phosph. + pot. sulph. in 1 dose.	1.8	7.2
Final height after 133 days.	Am. sulph. in 2 doses.	9.75	19.5	Am. sulph. + di-sod. hyd. phosph. in 1 dose.	11.0	44.25

B. **Depressing influences of treatments.**

Depression in	Treatments.	
	Indore 1	Malvi 9
Yield of seed cotton.	none	Am. sulph. 1 dose
Plant weight at 43 days.	Am. sulph. + pot. sulph. 2 doses pot. sulph. 1 dose and 2 doses, sod. nitrate 2 doses.	Sod. nitrate 1 dose, pot. sulph. 2 doses, di-sod. hyd. phosph. 1 dose, am. sulph. 2 doses.
Final height	Di-sod. hyd. phosph. 1 dose and 2 doses, pot. sulph. 2 doses.	Pot. sulph. 1 dose. ..

difying influence of components other than the nutrient elements.

	Yield.		Plant wt.		Final height.	
	Ind. 1	Malvi 9	Ind. 1	Malvi 9	Ind. 1	Malvi 9
Nitrogen alone						
am. sulph. 1 dose ..	9.1	1.7	6.0	1.4	13.75	23.0
sod. nitrate 1 dose ..	8.3	4.6	5.7	1.6	14.5	21.5
calc. nitrate 1 dose ..	8.7	11.85	3.9	2.4	14.5	34.0
Phosphates alone di-sod. hyd. phosph. 1 dose	5.3	6.45	3.8	1.2	8.5	13.5
super-phosph. 1 dose ..	7.8	8.0	2.9	2.1	13.5	18.0
am. sulph. + di-sod. hyd. phosph. 1 dose	7.2	19.3	7.0	5.4	11.5	44.25
Nitrogen plus phosphate.						
am. sulph. + di-sod. hyd. phosph. 1 dose ..	7.2	19.3	7.0	5.4	11.5	44.25
Nicifos 17/45 ..	12.50	16.25	3.3	3.4	15.25	29.0
Nicifos 22/18 ..	11.9	11.20	10.1	2.2	12.5	18.0

D. Influence of one nutrient element on another.

	Yield.		Plant weight.		Final height.	
	Ind. 1	Malvi 9	Ind. 1	Malvi 9	Ind. 1	Malvi 9
Am. sulph. + di-sod. hyd. phosph. 1 dose ..	7.2	19.3	7.0	5.4	11.5	44.25
Am. sulph. + pot. sulph. 1 dose ..	4.90	4.0	6.6	3.1	13.0	18.5
Am. sulph. + pot. sulph. + di-sod. hyd. phosph. 1 dose ..	14.1	3.9	13.0	7.2	14.5	30.0

E. Complete nutrient in different forms and with different ratios, NK: P_2O_5

	Ratio	Yield		Plant weight		Final height	
	N: K_2O: P_2O_5	Ind. 1	Malvi 9	Ind. 1	Malvi 9	Ind. 1	Malvi 9
Safflower cake ..	1 : 0.33 : 0.66	17.0	..	6.4	3.5	14.0	..
Municipal compost	1 : 1.4 : 1.7	11.0	14.6	5.4	3.5	11.0	22.25
Farm compost ..	1 : 3.4 : 0.58	6.5	6.10	6.4	2.1	10.0	18.0
Farm yard manure ..	1 : 3.9 : 1.7	5.6	7.3	4.2	2.9	14.5	16.0

F. Mode of application, one and two doses.

	Yield.		Plant weight.		Final height.	
	Ind. 1	Malvi 9	Ind. 1	Malvi 9	Ind. 1	Malvi 9
Am. sulph.						
1 dose ..	9.1	1.7	6.0	1.4	13.75	23.0
2 doses ..	21.2	14.4	3.6	1.7	19.5	25.0
Sod. nitrate 1 dose ..	8.3	4.6	5.7	1.6	14.5	21.5
2 doses ..	11.4	7.2	2.1	2.6	13.0	16.75
Di-sod. hyd. phosph. 1 dose ..	5.3	6.45	3.8	1.2	8.5	13.5
2 doses ..	4.20	3.0	2.8	3.8	9.0	11.5
Am. sulph. + di-sod. hyd. phosph. 1 dose ..	7.2	19.3	7.0	5.4	11.5	44.25
2 doses ..	7.7	7.7	10.3	2.2	15.5	25.5
Pot. sulph. 1 dose ..	4.97	4.40	2.1	2.6	14.0	10.5
2 doses ..	6.0	5.5	8.25	1.2	8.25	13.0
Am. sulph. + pot. sulph. + di -sod. hyd. phosph. 1 dose ..	14.1	3.9	13.0	7.2	14.5	30.0
2 doses ..	6.6	13.75	6.5	6.0	15.25	31.75
Am. sulph. + pot. sulph. 1 dose ..	4.90	4.0	6.6	3.1	13.0	18.5
2 doses ..	3.15	6.10	2.4	3.9	12.5	16.0

The following points were brought out by these pot-cultures :—

(1) The greatest plant weights for both varieties within a period of 43 days from germination were produced by complete nutrients given in one dose.

(2) Maximum seed cotton yields of Cambodia however were given with ammonium sulphate in two doses and of Malvi (No. 9) with a mixture of ammonium sulphate and di-sodium hydrogen phosphate in one dose.

(3) Maximum heights were given by those treatments which gave maximum yields.

(4) The yield of Cambodia was increased by all treatments. Ammonium sulphate in one dose, however, depressed it for Malvi 9.

(5) Plant weights at 43 days and final heights were lower than control with some treatments.

(6) Nutrients applied in different combinations gave different results, the varieties not always responding in the same way. Practically equal responses were obtained from treatments differing in the preponderant nutrient elements. Single nutrients sometimes gave the same result as that from a combination.

Absolute values (plant-weight) for the early start or the final growth (height) do not show any consistent relation to the total yield. The effect of nitrogen is influenced by the presence or absence of other elements (potash and phosphorus). The combination of nitrogen and phosphorus had a beneficial effect on Malvi 9 and to a certain extent on Cambodia. Different ratios between elements supplied in the same form have different effects but such different effects can also be produced by nutrients in the same ratio but in different forms.

For both the varieties the application of nitrogen and in some degree potash in two doses is better than in one dose but two applications of phosphorus have the reverse effect. Combinations of nitrogen and potash, and nitrogen, phosphate and potash, gave better results with Cambodia when applied in a single dose, but with Malvi 9 it was the reverse. The reponse to phosphorus is better than to potash. Nitrogen and phosphorus combined are better in one dose on Malvi 9 but on Indore 1 there is no difference between one and two doses.

An effective system of manuring will have to be based upon the correct intensity of nutrient supply, especially of nitrogen, and to a less extent phosphorus, in the early and later stages of growth.

The effect of the unabsorbed residues of the chemicals used (bases, acids, etc.) is known to be indirect, through their modifying influence on the physical condition of soil, hence it seemed necessary to determine the soil texture suitable for the utilisation of the nutrients,

The results of the 1934 experiment, which was intended to give further information in this direction, are tabulated below :—

TABLE 9.

Texture differences and nutrient efficiencies for cotton 1934-35.

Yield of seed cotton (*Kapas*) and plant weights are given in gms. per plant and heights in inches.

A

Indore 1.

Treatment.	No treatment.			Compost.			Acid.			Compost+Acid.		
	Yield Kapas.	Final plant weight.	Final plant height.	Yield Kapas.	Final plant weight.	Final plant height.	Yield Kapas.	Final plant weight.	Final plant height.	Yield Kapas.	Final plant weight.	Final plant height.
Nil ..	3.5	9.0	7.6	4.9	14.8	14.9	2.8	5.6	3.9	8.7	25.4	14.7
N ..	4.8	7.0	7.8	14.0	40.3	22.5	4.6	14.0	10.0	8.9	27.1	16.6
P ..	10.7	68.0	12.3	6.8	21.0	15.3	2.5	7.0	6.4	4.9	8.8	10.4
K ..	7.7	15.0	14.8	19.2	75.2	20.3	6.3	9.0	9.9	6.6	10.5	13.9
NP ..	15.6	41.9	29.2	18.7	93.6	26.4	7.0	13.1	14.1	7.6	15.7	14.2
NK ..	8.6	19.8	20.4	13.7	86.0	24.7	0.6	4.4	14.2	11.7	33.8	20.4

B.

Malvi 9.

Nil ..	2.8	5.2	13.0	6.3	13.1	32.4	1.3	1.7	16.1	5.9	26.2	33.5
N ..	3.2	28.8	11.0	13.9	15.1	56.7	4.0	10.0	20.7	12.1	32.3	38.7
P ..	2.7	15.7	21.2	6.3	25.2	36.5	1.3	4.0	12.5	3.8	8.7	24.5
K ..	2.3	4.2	15.0	9.9	25.3	31.2	5.4	20.1	10.9	5.6	24.5	31.1
NP ..	15.2	77.8	52.2	12.7	57.7	59.8	7.2	18.3	29.9	8.7	19.2	38.4
NK ..	3.9	23.6	38.8	13.4	64.0	50.7	3.2	7.0	17.0	6.8	61.2	49.4

Significances.

	P.
Treatments.	
Texture	<0.01
N & no N	<0.01
K & P	<0.01
Interactions.	
(N & no N)×(K & P)	<0.01
Texture × (N & no N)	<0.05
Texture × (K & P)	<0.01
Texture × (N & no N) × (K & P)	<0.01
Varieties × Texture	<0.05
Varieties × (K & P)	<0.05
*Varieties × Texture × (N & no N) × (K & P)	<0.01

*Sig. diff.=2.4 for mean yield of *kapas* per plant.

The clues given by the qualitative experiment of 1933 were amply confirmed. Cambodia showed a capacity to yield higher than Malvi 9. The highest yields of Cambodia were obtained in the presence of compost, supplemented either by potash alone or a mixture of nitrogen and potash; while Malvi 9 yielded its highest with nitrogen and phosphate in the absence of compost.

Several other points bearing upon cotton nutrition have been brought into relief:

Cambodia cotton :—

(i) Behaviour with nitrogen.

On ordinary black soil this nutrient had no appreciable effect and acid flocculation or combination with potash made no difference, but when combined with phosphate or with compost the yield rose nearly three times. The addition of compost to the combination of nitrogen and potash gave a similar increase and addition of compost to nitrogen and phosphate led to a still higher increase in yield. This favourable effect of compost on nitrogen alone and with phosphate and potash was reduced by acid flocculation. There was no difference between the single effect of compost and of nitrogen but acid flocculation with compost treatment nearly doubled the yield, in contrast with its effect on nitrogen. In the absence of compost, flocculation of soil reduced the yield by nearly one-third.

It is obvious that compost plays two rôles, (1) its physical influence on the soil; (2) its supply of nitrogen, phosphate and potash or their combinations according to requirements; a sort of balancing agent, preventing excess or deficiency of any one nutrient.

(ii) Behaviour with potash and phosphate.

The response to potash was higher than to nitrogen but lower than to phosphate. The addition of compost, however, to phosphate reduces the yield by one-third, but when added to potash yield is increased nearly two-and-a-half times.

(iii) Flocculation.

Flocculation by acid did not influence the response to potash in the absence of compost but prevented any benefit being derived from it. This is comparable to the similar effect of acid flocculation on compost—treated soils mentioned above, preventing them from deriving any benefit from added nutrients, presumably because of the nature of the flocculation induced by acid, contrasted with humic flocculation. This may be taken as an indication that the Cambodia crop with an adequate supply of nutrients demands a moisture supply free from the greater fluctuations resulting from acid flocculation.

Malvi (No. 9) Cotton.

(i) Nitrogen.

Nitrogen had no influence on yield, and flocculation by acid, or the addition of potash, made little difference, but in combination with phosphate the yields became almost five-fold and reached the maximum for the variety. Compost gave nearly twice as much yield as nitrogen but a combination of compost with nitrogen raised the yield to four times that from nitrogen alone.

(ii) Potash and Phosphate.

Like nitrogen, potash and phosphate alone had no influence on yield.

(iii) Flocculation by acids.

Flocculation by acids had no influence except in the presence of nitrogen and phosphate together or potash alone. Compost however reduced the response to nitrogen plus phosphate by 20% and with acid flocculation the yield was further reduced by 25% to the level of yields from acid alone. In combination with nitrogen, acid flocculation raised the yield one-and-a-half times but further addition of compost to the combination gave further increase to three times.

This probably indicates that any favourable influence of compost on Malvi 9 is through its power to supply nutrient and not so much to its effect upon moisture relation.

It appears that the conditions produced by compost in presence of all added nutrients are favourable for Cambodia but definitely unfavourable for Malvi, when the added nutrient is a combination of nitrogen and phosphate.

If the drying effect of compost alone on the soil is assumed to be less powerful than that of acid flocculation, it may be concluded that compost keeps the moisture at adequate levels except when, as with Malvi 9 treated with nitrogen and phosphate, the demand becomes too high.

TABLE 10.

Influence of green manure on the yields of wheat and cotton at Indore.

Variety—Malvi 1.

Yield in lbs. per acre.

Yield of	Green manures cut and removed				Green manures ploughed in				Fallow	P	Significant difference.
	Black gram	Sann	Soya-beans	Cow-peas	Black gram	Sann	Soya-beans	Cow-peas			
Total yield											
Wheat, 1932 ..	635	577	472	597	604	558	554	479	475	<0.05	104
Cotton, 1933 ..	540	522	517	547	588	528	566	486	442	>0.05	..
Yield of two pickings of cotton.											
(1st & 2nd.) ..	281	267	243	263	291	254	254	245	172	<0.05	54

(v) **Humus supply (field scale).**

Some of the investigations described in paras, (i) to (iv) above have also been studied under field conditions—the results are summarized below under the same headings. Green manuring followed by wheat in the same year and subsequently by cotton, gave higher total yields with wheat but not significantly with cotton, though the first two pickings yielded better with green manure. The rainfall was very heavy (51.82 inches) and it is possible that in normal years increases may also be obtained with total yields. (Table 10) .

(vi) **Soil texture.**

Both Malvi 9 and Cambodia, Indore 1 did not respond significantly to field applications of heated soil at five or twenty cartloads per acre. The doses were much smaller than those used for the small plots mentioned on p. 18. A test is being made to find the effect of heavier applications within the range of practicability.

Similarly, in another field test, flocculation by sulphuric acid gave no yield differences even when repeated twice during the crop period. Superphosphate behaved similarly.

The steady maintenance of favourable moisture conditions resulting from open texture cannot be brought about in Indore soils by mechanical means to ensure good drainage conditions. An experiment repeated for three years, consistently gave no significant differences in yields when attempts were made to keep open texture by providing shallow furrows at different intervals between rows of the growing crop to regulate drainage and soil aeration.

In the last three years very heavy rains spoiled several field experiments aimed at estimating the influence on the yields of cotton and other crops of:

(1) Previous crop;

(2) Interculture to keep mulches of different depths;

(3) Weeding;

(4) Intersowing of other crops.

The last year's experiment showed a significant detrimental influence due to absence of weeding, even when the rains had depressed the yields of the cotton crop to the lowest limit.

TABLE 11.

Response of common crops to interculture and weeding 1932-34.

Yields in lbs. per acre.

A.

Crop—Cotton.

Year.	Hand weeding only	Indore ridger & weeding	*Daura* & weeding	*Guntaka* & weeding	P.	Sig. diff.
1932 ..	265	270	225	248	>0.05	..
1934 ..	229	282	312	254	>0.05	..

B.

Crop—Jowar. (Sorghum).

1932						
Grain ..	149	148	251	216	<0.05	48
*Kadbi** ..	4340	4300	4280	3900	<0.05	437
1934.						
Grain ..	373	352	409	368	>0.05	..
Kadbi ..	1897	2068	2166	1971	>0.05	..

* Dry stems and leaves.

C.

Crop—Tuer. (*Cajanus indicus*—pigeon pea).

1933						
Grain ..	685	615	660	670	>0.05	..
Bhusa† ..	530	483	553	560	>0.05	..

† Straw and chaff.

D.

Crop—Cowpeas.

Year.	Hand weeding only	Indore ridger & weeding	*Daura* & weeding	*Guntaka* & weeding	P.	Sig. diff.
1933 Grain ..	135	116	146	130	>0.05	..

E.

Crop—Wheat.

1933						
Grain ..	330	343	251	228	>0.05	..
Bhusa ..	492	555	464	451	>0.05	..

F.

Influence of interculture and weeding on cotton (1933)
Variety, Malvi bulk—lbs. per acre.

Ridger & weeding	Ridger no weeding	*Daura* & weeding	*Daura* no weeding	Weeding alone	No weeding	P.	Sig. diff.
105.2 ..	10.4	86.4	2.1	60.1	3.1	<0.05	50.4

Shallow interculture either by *daura* or *guntaka* benefitted the *jowar* crop in 1933. This seems to be due more to the effective weeding done by these implements than to their capacity to produce a mulch. This has been confirmed by the results of another experiment in 1933,

TABLE 12.

Yield and growth of *jowar* (sorghum) as influenced by weeding and interculture.

Yields in lbs per acre.
1933

Variety—*Jowar*, Malvi.

	Ridger		*Daura*		No interculture.			
	Weeding	No weeding.	Weeding	No weeding.	Weeding	No weeding.	P.	Sig. diff.
Grain ..	181	161	137	100	198	59	<0.05	43.7
Kadbi ..	1934	1559	2259	2125	2334	1950	<0.05	407.8

The extreme importance of weeding is clear. The favourable influence of implements wherever it existed was solely due to their efficiency as weeders. A deeper mulch (Indore ridger) without weeding showed a detrimental effect; presumably due to competition for moisture between the crop and the weeds not removed by the implement.

The influence of cultivation during the cold weather on the crops of the following season has been studied since 1932. The types of cultivation compared were :—

(1) Opening the soil surface to about three inches—*desi* plough.

(2) Subsoiling.

(3) Soil inversion—Ransome's CT 2 plough and

(4) Subsoiling followed by opening the soil surface—with the *deis* plough.

The experiment has not yet run sufficiently long to show cumulative effects. Heavy rains in the last two years have depressed the cotton crop.

TABLE 13.

Yield response of common crops to winter cultivation.
Yield—in lbs. per acre.

A.

Crop—Cotton.

Year.	No cold weather cultivation	Country plough	Subsoiler	Inversion plough	Subsoiler & country plough	P.	Sig. diff.
1932.. ..	160	108	138	140	148	>0.05	..
1934.. ..	51	47	72	49	49	>0.05	..

B.

Crop—*Jowar* (sorghum).

1932 *Chari** ..	17430	17310	16310	17110	19450	>0.05	..
1934 Grain ..	319	204	335	218	263	>0.05	..

*The whole crop cut green.

C.

Crop—Groundnut.

1933 Nuts ..	418	354	423	330	351	>0.05	..
Bhusa ..	700	655	722	563	608	>0.05	..

D.

Crop—Cowpeas.

Year.	No cold weather cultivation	Country plough	Sub-soiler	Inversion plough	Sub-soiler & country plough	P.	Sig. diff.
1933 Grain ..	95	79	106	80	83	>0.05	..

E.

Crop—Wheat.

1933 Grain ..	646	554	692	956	722	>0 05	..
Bhusa ..	1548	1573	1611	1878	1563	>0.05	..

So far as the results go, however, there seems to be no immediate effect of any type of winter cultivation on the succeeding crop.

vii. **Nutrients (field scale).**

At Indore a complex expeiiment with six factors was carried out on Malvi 9 cotton in a rich field in 1934. The general cotton yields were very low and the results obtained are naturally indicative of what may be expected in similar seasons. The following comparisons, with their interactions were included :—

(1) different depths of interculture (*daura* or "Indore ridger").

(2) row spacings (14 and 21 inches).

(3) artificial manure.

(4) organic and inorganic manure (safflower cake and Nicifos 22/18).

(5) units of nitrogen ($7\frac{1}{2}$ and 15 lbs. per acre) and

(6) method of application (broadcast and drilled).

TABLE 14.

Response of Malvi 9 cotton to manures, 1934.

Yield—lbs. per acre.

With manures	Without manures	P	Sig. diff.
448	319	<0.05	40.1

Significant differences in yields were obtained only by manuring. Unless it is found otherwise in seasons of different type, a great latitude seems to be available for choosing the method of interculture and the kind of manure (the differences between which were not significant). The present seed rate of twenty lbs. per acre could perhaps be reduced to thirteen with saving of labour and time required for sowing. The labour of application of manures can be reduced by drilling them in and an increase of about 40 percent in yield was obtained at a cost per acre of Rs. 3-2 with Nicifos 22/18 (at Rs. 8-6 per cwt.) and Rs. 4-3 with safflower cake containing 2.6% N (at Rs. 33 per ton).

At Dhar, however, yields of Malvi cotton were significantly lower with cake than with Nicifos (22/18), yields for the control not significantly differing from either. This experiment was located on shallow eroded soil on the lower slope of a hill and hence liable to severe run-off. Under such conditions the utility of manure is not likely to be great.

With Cambodia (bulk seed) there was an opposite result; safflower cake gave significantly higher yields than both control and Nicifos (22/18).

TABLE 15.

Yield differences due to manures.

Dhar 1934.

lbs. seed cotton per acre.

Variety.	Treatments.			P	Sig. diff.
	Control	Nicifos 22/18	Saf-flower cake		
Malvi bulk ..	630	692	541	<0.05	126.2
Cambodia bulk ..	403	391	474	<0.05	62.2

A similar experiment at Jaipur with Cambodia Indore 1, in addition to confirming the superiority of earlier sowings recorded in 1934 showed either no differance or actual yield depression with Nicifos (22/18) while, in contrast with Dhar results, yields with cake, though usually higher than control, reached significance only for the April-sown, closely-spaced crop.

TABLE 16.

Sowing dates, manures and yields of cotton.
Jaipur, 1934.

Kapas in lbs per acre.

Plant spacings	Sowing dates								
	22nd April			15th May			2nd July (Rains)		
	Nicifos 17/45	Castor cake	Control	Nicifos 17/45	Castor cake	Control	Nicifos 17/45	Castor cake	Control
12 inches..	949	1486	813	537	784	696	305	271	303
18 inches..	537	1074	1092	337	955	722	313	417	281

Significances.	P	Sig. diff.
1. *Sowing dates	>0.05	..
2. *Manures	>0.05	..
3. Sowing dates × manures × spacings.	<0.05	329.

Other factors and interactions are insignificant

*Approaches significance.

It will be seen that the response of Cambodia is similar to that observed in pot cultures, i.e., a continued supply of nitrogen favours it, while Malvi cotton responds better to a single dose of nitrogen together with phosphate ; the response to nutrients depends upon the soil texture and associated moisture capacities.

In nitrification tests at Indore already reported† it has been shown that nitrification of the same manure continues longer in Malwa soil than in Jaipur soil. The better response of Cambodia cotton to cake at Dhar than at Jaipur confirms this in the field.

It is quite clear from the foregoing field results that for the present, it is likely to be profitable to concentrate chiefly on the investigations in cotton nutrition and manuring.

† "Nitrogen balance in Black soils" III, Wad. Y. D. and Aurangabadkar R. K. Report, Proc. Ind. Sci. Cong. 1935 (in publication).

Rotation for cotton.—The experiment was started in 1932 and subsequently re-cast in 1933. It comprises five alternative rotations of cotton with *jowar*, (sorghum), *tur*, (pigeon pea), groundnut, cowpeas and wheat. Started at two points, the full cycle will be complete in 1936 and will then be reported. The separate experiment—the influence on cotton of seven different preceding crops—has been completed but results are not yet examined; the cotton plots of 1934 yielded very low.

C. Cotton nutrition in relation to environment—Quality.

The data from pot cultures of 1934 are not yet statistically examined; they deal with the influence of soil texture, humus supply and nutrients upon the lint length and ginning percentage of Cambodia and Malvi cottons.

Similar data, however, from field experiments at Dhar and Jaipur are discussed below :—

Cambodia:—

The influence of environment on staple length was determined on the seed cotton obtained from each treatment in the Jaipur experiment (page 37) with the following results :

TABLE 17.

Influence of environment on staple length—Jaipur, 1934.
Variety—Cambodia Indore 1.

A.

Mean staple length in mm.

Sowing dates.	Manure.				No manure	
	Castor cake		Nicifos 17/45		Plant spacing	
	Plant spacing.					
	12 in.	18 in.	12 in.	18 in.	12 in.	18 in.
April ..	25.6	21.8	24.8	24.2	22.3	22.6
May ..	24.8	24.8	24.5	23.0	23.5	23.0
On rains ..	23.6	22.7	26.3	24.7	24.9	25.5

Rates of manures applied : 21 lbs. of nitrogen per acre, i.e., 6 cwt. of castor cake (N=3%) or 150 lbs. of Nicifos 17/45 per acre.

Significances,		P.	Sig. diff.
(a)	Sowing dates	<0.05 (<0.01)	0.71
(b)	*Manures	>0.05	—
(c)	Spacings	<0.05	0.56
(d)	Sowing dates × manures ..	<0.05 (<0.01)	1.41
(e)	Manures × spacings ..	<0.05	0.98

Other interactions are insignificant.

*Approaches significance.

(d) Sowing dates × manures.

Manures	22nd April	15th May	2nd July
Control	22.5	23.2	25.2
Nicifos 17/45	24.5	23.7	25.5
Castor cake	23.7	24.8	23.2

(e) Manures × spacings.

Spacings	Control	Nicifos 17/45	Castor cake
12 inches	23.6	25.2	24.6
18 inches	23.7	23.9	23.1

The use of manure has maintained a steadier and higher level at almost all sowing dates, closer spacing nearly always giving a longer staple. Without manure, staple length diminished with each earlier sowing, equally for both spacings. Rain-sown crops with Nicifos or no manure gave higher lengths. The kind of manure had different effects at different sowing dates.

Castor cake gave a longer staple on the May-sown crop than that sown on rains but Nicifos raised the staple length of rain-sown cotton to the highest level in the trial.

Considering the following points :—

(1) the rates of nitrification of inorganic and organic manures,

(2) the differences in moisture in hot weather and monsoon,

(3) the higher rate of nitrification in hot weather and

(4) the differences in evaporation of soil moisture due to spacing during the boll-developing stage i. e., after the rains cease.

It appears that an ample supply of nitrogen with sufficient moisture in the early stages has a favourable influence on staple length.

The results obtained on staple length of the Cambodia crop in the Dhar experiment (page 36) are given below.

TABLE 18.

Influence of environment on staple length—Dhar, 1934.

Variety—Cambodia (Local unselected).

Staple length in mm.

Plant spacing.	Single unit of manure*	Double unit of manure†	No manure	Mean for spacing.
12 inches ..	19.1	20.9	19.3	19.8
18 inches ..	18.8	18.5	18.7	18.7

*Single unit: 7½ lbs. nitrogen per acre i. e., 290 lbs. of safflower cake (N=2.6%) or 42 lbs. Nicifos 22/18 per acre.

† Double unit: double the above quantities.

Significance :

Plant spacings—P <0.05, sig. diff.$=1.0$ mm.

Plant spacings × Units of cake and Nicifos 22/18.

Experimental $Z=0.7087$, Z required$=0.7205$ for

$P=0.05$

The crop was poor, due to the effect of heavy rains on soil already exhausted by two sugarcane ratoons, both Leaf-roll and Red-leaf were severe and the lint was weak. The differences due to treatments were therefore generally masked by this severe depression. In spite of this, close spacing again gave longer staple and there is an indication that at close spacing, a higher rate of manuring is likely to lengthen the staple.

This also confirms the suggestion of the favourable effect of initial nitrogen supply and of soil moisture during boll-development.

The results were much more definite in the Dhar experiment with the hardier Malvi cotton (Page 36). They are tabulated below.

TABLE 19.

Influence of environment on staple length—Dhar, 1934.

Variety—Malvi 9.

A. Mean staple length in mm.

Plant spacings	Manure.				No manure
	Safflower cake		Nicifos 22/18		
	Single unit*	Double unit†	Single unit	Double unit.	
6 inches	19.3	19.2	17.1	18.5	18.6
12 inches	19.2	19.3	16.2	19.0	16.2

*Single unit : 7½ lbs. nitrogen per acre i. e., 200 lbs. of *safflower* cake (N=2.6%) or 42 lbs. Nicifos 22/18 per acre.

† Double unit : double the above quantities.

Significances:

		P
	Quality of manure	<0.01
	Units of manure	<0.01
A.	Quality × units of manure	<0.05
	Spacings	<0.01
B.	Spacings × units of manure .. .. .. Sig. diff.=0.89	<0.01
C.	Spacings × quality × units of manure .. .. Sig. diff.=1.2 mm.	<0.01

B.

Mean staple length in mm. per plot.

Plant spacings × units of manure.

Plant spacing 6 inches			Plant spacing 12 inches.		
No manure	Single unit	Double unit	No manure	Single unit	Double unit.
18.58	18.20	18.82	16.18	17.66	19.12

C.

Plant spacings × kind of manure × units of manure.

Plant spacings.	Safflower cake.		Nicifos—22/18	
	Single unit.	Double unit.	Single unit.	Double unit.
6 inches	19.32	19.16	17.08	18.48
12 inches	19.16	19.28	16.16	18.96

When closely spaced and without manure the crop gave a staple equal to some of those given by manures but the widely spaced crop (without manure) gave the lowest lint length. Nicifos in one unit at the same wide spacing made no difference, but raised it appreciably when the spacing was reduced. Cake at both rates and both spacings gave high staple lengths, higher than a single unit of Nicifos at both spacings and no manure at wider spacing. The double rate of Nicifos behaved in a similar manner. Unlike its effect on the Cambodia crop at Jaipur, cake has given good results with both spacings, while the effect of Nicifos increases with rate and not with spacing. It is difficult to say whether this is due to the use of Safflower cake, instead of castor as at Jaipur, or to the differences in variety and environment.

D. Cotton nutrition in relation to environment—the development of the plant.

Field experiments carried out in 1933 at Indore and several other places in Malwa and Rajputana showed the possibility of obtaining yields from rains-sown cotton equal to those from summer sowings. Thus it appeared that though the greater intensity of photo-synthesis in a crop started in bright summer might be partly responsible for the high yields obtained, a crop receiving less light in the cloudy monsoon could also exhibit a similar performance under certain conditions. It was considered that a clear understanding of the interactions between photosynthetic activity and other environmental factors might supply definite 'pointers' for work on cotton improvement suited to different local conditions.

Three varieties, Malvi 9, Cambodia Indore 1, and Punjab-American cotton (P. 289F), were grown in the open in pots,

(i) in sand manured with safflower cake and complete inorganic nutrients and

(ii) in black cotton soils manured with compost on an equivalent nitrogen basis.

One set was sown at the end of May and another in the beginning of July. Half the number of plants in each set was exposed after daylight to continuous illumination with one 200-watt Crompton gas-filled pearl lamp per pot up to the maturing stage (end of November 1934).

Illumination for about a month produced symptoms of nutrient starvation in the plants and hence two applications of complete nutrients were given to all pots at monthly intervals. During dry weather, the pots were watered according to their observed requirements.

Total figures for all observations taken during and after the period of illumination are given in Table 20, A to C.

The records of bud-production, shedding, total yield and vegetative growth for all the varieties are discussed below :—

Total bud production:

Malvi : Maximum bud production was obtained with illumination for both sowings in soil and with or without it for May-sown sand cultures; with other treatments bud-production was nearly 50% less.

Cambodia : Illumination doubled the production for July soil plants but did not much affect the production (high or low) of the other treatments.

P 289F : The total number of buds was low in general and illumination seemed to be unfavourable, especially for the July soil culture.

It appears that a favourable effect, equivalent to that of increased photosynthetic activity, can be produced without it when high nitrification can be maintained (whether by summer sowing or by use of sand). Malvi fares best with illumination and P. 289F worst with equal nitrogen supply.

Shedding:

With all the varieties, the changes observed were similar to those of bud-production but sometimes differed in degree.

TABLE 20.

Environment and the development of the cotton plant.

A. Malvi 9.

Description	Summer-sown (30-5-34)				Rain-sown (4-7-34)			
	Soil		Sand		Soil		Sand	
	Un-illuminated.	Illuminated.	Un-illuminated.	Illuminated.	Un-illuminated.	Illuminated.	Un-illuminated.	Illuminated.
I. Up to 29-11-34.								
(1). Total bud production ..	78	144.3	152	162.3	80.5	165	78	8.5
(2) Total shedding ..	56	103	107	106	31	77	46	56
(3) Interval (days) between date of sowing and beginning of shedding ..	90	23	90	41	56	90	56	90
(4) Period of shedding (days) ..	90	159	90	140	90	56	90	56
(5) Rate of shedding (per day) Item 2÷by Item 4	0.62	0.65	1.2	0.75	0.34	1.4	0.44	1.0
(6) Percentage of shedding on total bud production	71.8	71.3	70.4	65.3	38.5	46.7	59.0	65.9
(7) Yield of seed cotton in gms. ..	12.6	0.3	15.3	1.1	1.8	..	..	..

A. Malvi 9—(*contd.*)

Description	Summer-sown (30-4-34)				Rain-sown (4-7-34)			
	Soil		Sand		Soil		Sand	
	Un-illuminated	Illuminated	Un-illuminated	Illuminated	Un-illuminated	Illuminated	Un-illuminated	Illuminated
(8) Number of mature bolls	8	0.3	12	1.3	1.5	..	..	..
(9) Number of green bolls present on 29-11-34 ..	12	2	3	4	40	6	29	1
(10) Seed cotton per boll in gms. ..	1.6	1.0	1.3	0.85	1.2	..	..	..
II. From 29-11-34 to 27-2-35								
(1) Yield of seed cotton (gms). ..	16.2	8.3	7.7	4.3	46.0	5.3	47.2	2.9
(2) Number of mature bolls	12.7	10	7.3	9.3	40	4	22.5	2.5
(3) Seed cotton per boll (gms) ..	1.3	0.83	1.05	0.46	1.15	1.32	2.09	1.16
III.								
(1) Total yield of seed cotton (gms)	28.8	8.6	23.0	5.4	47.8	5.3	47.2	2.9
(2) Total number of mature bolls ..	20.7	10.3	19.3	10.6	41.5	4	22.5	2.5
(3) Seed cotton per boll (gms) ..	1.4	0.8	1.2	0.5	1.15	1.3	2.1	1.2
IV. Vegetative growth.								
(1) Shoot-length per bud in inches	2.6	1.9	2.1	1.8	3.0	2.1	2.6	2.2

TABLE 20—(*contd.*)

Environment and the development of the cotton plant.

B. Cambodia, Indore 1.

Description	May-sown (30-5-34).				July-sown (4-7-34).			
	Soil		Sand		Soil		Sand	
	Un-illuminated.	Illuminated.	Un-illuminated.	Illuminated.	Un-illuminated.	Illuminated.	Un-illuminated.	Illuminated.
I. Up to 29-11-34								
(1) Total bud production ..	105	128.3	136.7	108	77	126	76	63
(2) Total shedding ..	91	105	108	93	66	84	58	57
(3) Interval (days) between date of sowing and beginning of shedding ..	40	22	40	22	58	58	58	90
(4) Period of shedding (days) ..	142	160	142	160	90	90	90	58
(5) Rate of shedding (per day) Item 2÷by Item 4 ..	0.64	0.66	0.76	0.58	0.75	0.93	0.64	0.98
(6) Percentage of shedding on total bud production ..	86.7	81.8	79.0	86.1	85.7	66.7	76.3	90.5

B. Cambodia, Indore 1.—(*Contd.*)

Description	May-sown (30-5-34).				July-sown (4-7-34).			
	Soil		Sand		Soil		Sand	
	Un-illuminated.	Illuminated.	Un-illuminated.	Illuminated.	Un-illuminated.	Illuminated.	Un-illuminated.	Illuminated.
(7) Yield of seed cotton in gms. ..	11.6	0.7	20.9	..	..	..	..	..
(8) Number of mature bolls	4.7	0.3	7.7	..	..	..	..	..
(9) Number of green bolls present on 29-11-34..	6	4	8	2	11	11	5	1
(10) Seed cotton per boll in gms. ..	2.5	2.3	2.7	..	..	..	..	..
II. From 29-11-34 to 27-2-35								
(1) Yield of seed cotton (gms.) ..	12.2	..	9.5	0.6	45.6	19.3	21.5	5.9
(2) Number of mature bolls	5.7	..	5.3	0.3	18	8	10	4.5
(3) Seed cotton per boll (gms.) ..	2.1	..	1.8	2.0	2.5	2.4	2.15	1.3
III.								
(1) Total yield of seed cotton (gms.) ..	23.8	0.7	30.4	0.6	45.6	19.3	21.5	5.9
(2) Total number of mature bolls ..	10.4	0.3	13.0	0.3	18	8	10	4.5
(3) Seed cotton per boll (gms.) ..	2.2	2.3	2.3	2.0	2.5	2.4	2.15	1.3
IV. Vegetative growth.								
(1) Shoot-length per bud in inches.	1.8	2.1	1.9	2.3	2.8	2.9	2.1	4.2

TABLE 20—(*Contd.*)

Environment and the development of the cotton plant.

C. Punjab American P. 289 F.

Description	May-sown (30-5-34).				July-sown 4-7-34).			
	Soil		Sand		Soil		Sand	
	Un-illuminated	Illuminated	Un-illuminated	Illuminated	Un-illuminated	Illuminated	Un-illuminated	Illuminated
I. Up to 29-11-34								
(1) Total bud production ..	96	81	90	84	78	35	65.5	68
(2) Total shedding	61	78	70	79	47	25	51	56
(3) Interval (days) between date of sowing & beginning of shedding ..	40	40	40	40	58	90	58	90
(4) Period of shedding (days)	142	142	142	142	90	58	90	58
(5) Rate of shedding (per day). Item 2÷by Item 4 ..	0.43	0.55	0.49	0.56	0.52	0.43	0.56	0.97
(6) Percentage of shedding on total bud production ..	63.5	96.3	77.8	94	60.2	71.4	77.8	82.4
(7) Yield of seed cotton in gms. ..	17.8	..	15.4	..	3.6	..	1.5	..
(8) Number of mature bolls	7	..	8.7	..	2	..	0.5	..
(9) Number of green bolls present on 29-11-34 ..	14	1	2	..	10	..	8	..

C. Punjab American P. 289 F.—(*Contd.*)

Description	May-sown (30-5-34).				July-sown (4-7-34).			
	Soil		Sand		Soil		Sand	
	Un-illumi-nated.	Illumi-nated.	Un-illumi-nated.	Illumi-nated.	Un-illumi-nated.	Illumi-nated.	Un-illumi-nated.	Illumi-nated.
(10) Seed cotton per boll in gms. ..	2.5	..	1.8	..	1.8	..	3.0	..
II. From 29-11-34 to 27-2-35.								
(1) Yield of seed cotton (gms.) ..	22.1	..	5.6	..	35.1	..	18.4	..
(2) Number of mature bolls ..	9	..	3.3	..	14.5	..	6.5	..
(3) Seed cotton per boll (gms.) ..	2.5	..	1.7	..	2.4	..	2.8	..
III.								
(1) Total yield of seed cotton (gms.)	39.9	..	21.0	..	38.7	..	19.9	..
(2) Total number of mature bolls	16	..	12.0	..	16.5	..	7.0	..
(3) Seed cotton per boll (gms). ..	2.5	..	1.75	..	2.3	..	2.8	..
IV. Vegetative growth.								
(1) Shoot-length per bud in inches	2.1	2.7	1.7	3.3	2.8	4.9	1.2	2.5

Illumination hastened shedding in the May-sown plants of Malvi and Cambodia but delayed it in all the July sowings, except Cambodia in soil. The rate of shedding in July sowings was generally higher with illumination, differing in degree according to variety.

The percentage of shedding in Malvi plants was increased by May sowing and by illumination on July sowings. It was not affected much by May sowing with Cambodia or P. 289F but illumination lowered it for July-sown Cambodia plants in soil, and increased it greatly in P. 289F.

Total yield of seed cotton.

Yields were always depressed by illumination, P. 289F suffering most and July-sown Cambodia the least.

The stimulating influence of light did not extend beyond bud-production.

Shoot-length per bud.

Shoot-length per bud was calculated by dividing the total length of all shoots as measured at the end of November by the total number of buds produced up to that time.

Illumination depressed the shoot-length per bud in Malvi but increased it for the American cottons.

July sowings with their greater initial moisture increased shoot-length per bud with both soil and sand for Malvi and Cambodia, but for P. 289F, it increased on soil but decreased on sand. Irrespective of variety, season and illumination, shoot-length per bud was depressed by sand wherever yields were high but not otherwise. On the other hand in either sand or soil it rose with yield of Malvi plants and fell with that of American.

There seems to be a particular shoot-length per bud that is optimum for high-yielding capacity, the actual value being perhaps higher, (i) for soil than for sand in the same season and, (ii) higher for Malvi than American cottons growing under similar conditions. This suggests a probability of there being an optimum dry weight production, probably of a definite composition, to enable each bud to reach maturity.

E. Crop vigour and seed quality.

Yield differences in groundnuts (taken as a convenient indicator crop) due to localities were found associated with similar differences in oil contents. Crops from different places varying in yield and oil content showed different proportions of nuts apparently of different quality.

TABLE 21.

Yield and oil content of groundnuts grown in different localities.

Variety—Akola 10.

Locality.	Yield in lbs. per acre.	% oil.
Indore ..	1566	49.5
Datia ..	3050	49.6
Dhar ..	617	47.0
Bharatpur ..	483	47.2
Sitamau ..	....	43.6

The nuts from one crop were sorted into three grades and shelled. The kernels from each grade showed distinct differences in appearance—colour, plumpness, size and brightness, and there were very large differences in the oil contents.

TABLE 22.

Differences in oil content in different grades of groundnut.

Variety—Akola 10.

Grade.	% oil.
1st ..	44.5
2nd. ..	37.2
3rd ..	30.3

Several replicated field trials were made in 1934 to test if such differences persisted in the succeeding crop and how differences in varietal habit and field fertility would react upon them.

Some of the results have now been examined.

TABLE 23.

Yield vigour as influenced by seed quality.

Mean yields in grams per plant.

Grades	Rich field.				Poor field.			
	Akola 10	Gan-gapuri	Spa-nish pea-nuts	Total	Akola 10	Gan-gapuri	Spa-nish pea-nuts	Total
1st grade ..	46.6	51.7	20.3	118.6	23.8	11.5	15.7	51.0
2nd ,, ..	39.6	40.1	17.5	97.2	24.2	13.6	16.9	54.7
3rd ,, ..	34.0	45.0	10.4	89.4	22.0	10.5	16.1	48.6
Total ..	120.2	136.8	48.2	305.2	70.0	35.6	48.7	154.3

Significance (1) fields (2) varieties (3) grades P. <0.05.

Sig. diff. (1) 72.40 (2) 54.26 (3) 12.72.

Other results are not significant.

Irrespective of variety, high-quality seeds gave higher yields in a rich field but the lowering of yield in a poor field wiped out the differences. Spanish peanuts showed the least yield differences between grades, and none between fields—this variety has yielded lowest of those tested. This shows that the difference in seed quality appreciably affects the yields of future crops except when the crop growth is extremely poor. Other observations taken but not yet examined, such as the moisture contents in the nuts and kernels at harvest, and the shelling percentage, are likely to reveal how such differences are produced. The seed of a non-responsive variety like Spanish peanut, however, seems to remain unaffected. There is ground for the belief that cotton behaves in the same way as groundnuts.

F. Cropping power and soil characteristics.

(i) Similarities of different soils.

An attempt was made to find out whether any characteristics could be found common to different soils and tending to increase the yielding power of cotton. Both different types of soil from different tracts and the same type exhibiting differences due to treatment were compared.

Profile samples were collected in the field in Dhar and Jaipur States and at Indore from Field No. 31. Those were compared among themselves and with samples taken after harvest from Cambodia cotton plots at Indore, with and without heated soil treatments (50% in the top 6 ins). Determinations for hygroscopic moisture (50% humidity), total nitrogen and base exchange capacity were made.

TABLE 24.

Similarities of different soils.

Description of soil.	Hygroscopic moisture % on oven-dry basis.	Total nitrogen % on oven-dry basis (milligrams)	Base-exchange capacity, milli-equivalents per 100 gms. of air-dry soil.
(a) Dhar soil 0″—12″ ..	6.34	40.50	49.43
,, ,, 12″—24″ ..	7.57	34.60	50.20
,, ,, 24″—36″ ..	7.20	36.70	46.26
,, ,, 36″—48″ ..	6.43	28.90	47.87
,, ,, 48″—60″ ..	7.70	23.80	50.46
(b) Jaipur soil 0″— 6″ ..	1.31	12.7	9.55
,, ,, 6″—15″ ..	1.20	10.4	7.74
,, ,, 15″—24″ ..	2.10	10.6	11.60
,, ,, 24″—36″ ..	2.30	10.7	14.39
(c) Heated soil Treatment			
Indore 0″— 6″ ..	3.46	144.00	66.22
,, ,, 6″— 9″ ..	4.57	87.50	74.14
,, ,, 9″—15″ ..	5.32	86.80	72.86
,, ,, 15″—21″ ..	4.86	78.39	88.94
,, ,, 21″—24″ ..	5.01	72.00	74.28

Similarities of different soils.—(*Contd.*)

Description of soil.	Hygroscopic moisture % on oven-dry basis.	Total nitrogen milligrams per 100 gms. of oven-dry soil.	Base-exchange capacity, milli-equivalents. per 100 gms. air-dry soil.
(d) No treatment—control for (c) .. 0″— 6″ ..	4.75	81.00	82.16
,, ,, 6″— 9″ ..	4.91	66.00	86.28
,, ,, 9″—15″ ..	6.07	88.00	81.14
,, ,, 15″—18″ ..	5.81	86.00	74.92
,, ,, 18″—24″ ..	5.59	59.00	74.70
(e) Indore I.P.I. Field 31. 0″—12″ ..	7.75	36.00	56.89
,, ,, 12″—24″ ..	7.10	38.10	52.47
,, ,, 24″—36″ ..	7.71	28.00	58.05
,, ,, 36″—48″ ..	6.64	22.50	54.10
,, ,, 48″—60″ ..	7.48	20.20	56.64

Hygroscopic moistures were less in the upper than in the lower layers in Jaipur and Dhar soils, and greatest in the upper layer of Field 31. Heated soil reduced it.

The total nitrogen content of the Jaipur and Dhar soils was higher in the upper layer, but at Indore in the second layer. Heated soil raised it in the upper layer. It also seems that the base-exchange capacity is lowered up to 15 ins. depth by the heated soil treatment; perhaps the similar lower level in the Dhar profile is the result of similar processes, as the soil type is the same.

The carbon content was less following heated soil and a Cambodia crop; it increased with manures and to a greater depth with heated soil.

The carbon-nitrogen ratio was loweraftcr a Cambodia crop than Malvi. Heated soil and manures each intensified this difference with Cambodia. The combined effect of heated soil and manure was to raise the C/N ratio, and with Malvi to lower it—below nine inches—more than either treatment alone. The increases observed in the C/N ratio may be presumed to be due mainly to the depletion of nitrogen by crop growth, either or both by direct absorption and by its influence on soil processes,

The conductivity ratio between one-month and 24-hour water extracts shows reduction to a greater depth in control plots with Cambodia than with Malvi. With each variety manure and heated soil separately increased it in upper layers but no further when together.

ii. Soil profile changes by cropping and treatments.

Profile soil samples from the experiment on the influence of open surface texture (pp. 18, 20) were sampled after harvest and examined (Table 25, A & B).

Hygroscopic moisture was reduced in the upper layers by heated soil, by manure and by the growth of the Cambodia variety.

The total nitrogen distribution seems to show that with heated soil and also with a Cambodia crop, manure penetrated more deeply. When Cambodia grew with heated soil and manure, the total nitrogen figures show a general reduction, indicating its greater utilization. Malvi has exhausted the nitrogen of the heated soil plots, both manured and unmanured, more than the corresponding untreated plots and more than the Cambodia crop under similar conditions. The exhaustion due to Cambodia is greater in the unmanured control than the corresponding manured plots, but not so with Malvi.

Base-exchange capacity is reduced by treatment and manures in the Cambodia plots, the reduction in the surface layer being less in the manured plots with heated soil. Compared with Cambodia, Malvi shows lower values in control plots and with heated soil in the upper three-inch layer; added manure raises them throughout the profile (without heated soil). There seems to be a relationship between the base-exchange values and the plot yields, inverse for the preceding year (1933) and direct for the next year.

TABLE 25.

Soil profile changes by cropping and treatments A—Cambodia.

UNMANURED.

Depths	Heated Soil: Hygroscopic moisture %	Heated Soil: Nitrogen %	Heated Soil: Carbon %	Heated Soil: C/N	Heated Soil: Conductivity ratio	Heated Soil: Base-exchange capacity	Depths	Control: Hygroscopic moisture %	Control: Nitrogen %	Control: Carbon %	Control: C/N	Control: Conductivity ratio.	Control: Base-exchange capacity
0″— 6″	3.46	0.14	0.22	1.96	2.24	66.22	0″— 3″	5.16	0.098	0.26	2.63	1.6	82.16
6″— 9″	4.56	0.09	0.25	2.92	2.06	74.14	3″— 6″	4.33	0.062	0.26	4.2	1.9	..
9″—15″	5.32	0.087	0.13	1.05	1.78	72.86	6″— 9″	4.90	0.065	0.40	6.2	2.0	86.28
15″—21″	4.86	0.078	0.25	3.22	1.78	88.94	9″—15″	6.06	0.088	0.30	3.41	2.15	81.14
21″—24″	5.01	0.072	0.25	3.33	1.83	74.28	15″—18″	5.80	0.086	0.24	2.85	1.9	74.92
							18″—24″	5.58	0.059	0.34	5.8	2.0	74.70

MANURED.

Depths	Heated Soil: Hygroscopic moisture %	Heated Soil: Nitrogen %	Heated Soil: Carbon %	Heated Soil: C/N	Heated Soil: Conductivity ratio	Heated Soil: Base-exchange capacity	Depths	Control: Hygroscopic moisture %	Control: Nitrogen %	Control: Carbon %	Control: C/N	Control: Conductivity ratio.	Control: Base-exchange capacity
0″— 3″	4.33	0.092	0.31	3.4	2.1	67.76	0″— 3″	4.20	0.098	0.31	3.23	2.65	66.94
3″—15″	4·51	0·075	0·25	3·85	2·08	61·56	3—12″	5·15	0·081	0·14	1·73	2·60	69·69
15″—21″	3.84	0.063	0.25	4.0	1.78	66.33							
21″—24″	4.78	0.06	0.29	4.9	1.86	63.69	12″—24″	4.6	0.075	0.15	2.02	2.2	67.81

B. Malvi.

Unmanured.

Depths	Heated soil: Hygroscopic moisture %	Nitrogen %	Carbon %	C/N	Conductivity ratio.	Base-exchange capacity	Depths	Control: Hygroscopic moisture %	Nitrogen %	Carbon %	C/N	Conductivity ratio.	Base-exchange capacity
0″— 3″	5.28	.090	.57	6.4	2.15	64.92	0″— 3″	5.61	.14	.59	4.10	1.76	69.44
3″—15″	7.29	.064	.46	7.14	2.38	74.48	3″— 9″	5.58	.11	.60	5.33	2.35	71.18
15″—18″	..	.084	.69	8.23	2.00	72.44	9″—15″	5.96	.10	.37	3.63	2.17	68.50
18″—24″	7.88	.067	.39	5.86	2.09	78.52	15″—18″	5.84	.10	.34	3.22	2.68	73.56
							18″—21″	6.04	.10	.45	4.38	1.92	74.06
							21″—24″	6.14	.11	.42	3.62	1.85	74.58

Manured.

Depths	Heated soil: Hygroscopic moisture %	Nitrogen %	Carbon %	C/N	Conductivity ratio.	Base-exchange capacity	Depths	Control: Hygroscopic moisture %	Nitrogen %	Carbon %	C/N	Conductivity ratio.	Base-exchange capacity
0″— 3″	5.52	.097	.73	7.5	2.21	72.96	0″— 3″	6.49	.14	1.07	7.90	2.45	71.62
3″— 9″	7.69	.089	.77	8.5	2.31	69.40	3″— 9″	7.22	.11	.74	6.92	2.61	72.22
9″—15″	7.92	.067	.38	5.6	2.13	67.22	9″—15″	7.70	.079	.69	8.91	2.31	72.24
15″—21″	6.29	.069	.33	4.8	1.94	70.56	15″—24″	7.31	.070	.59	8.41	2.07	71.20
21″—24″	7.42	.071	.53	7.5	1.50	80.02							

The investigation of these soils is being continued, but the changes in soil texture, degree of fertility, nutrient content and efficiency of clay complex due to the treatments as well as to the residual effect of the crops grown, seem to be clearly reflected and localised in the soil profile. The superficial root system of Cambodia cotton seems to be acting in the same manner as heated soil treatment.

iii Soil moisure and crop growth.

In 1932, observations were taken to estimate the capacity for moisture retention of three typical fields at the Institute, Field 31 (black soil, two to three feet deep), Field 22 (dark grey, two to three feet deep, liable to surface wash) and Field 40 (well drained, light grey and seven to fifteen feet deep). Samples of soil were taken on the 29th August from 0—3 inches depth, and a month later from 9-12 inches in addition, after rainless periods of two and three weeks respectively. Results are given below :—

TABLE 26.

A.

Mean percentage moisture in fresh samples.

Depths of sampling.	29-8-32			29-9-32		
	Field 22	Field 31	Field 40	Field 22	Field 31	Field 40
0″— 3″ ..	29.13	28.85	25.10	22.95	25.18	22.72
9″—12″ ..	..	..	..	22.02	22.67	20.07

Significances:		P.	Sig. diff.
Fields	..	<0.01	....
Dates	..	<0.01	....
Depths	..	<0.01	....
B. Fields × dates	..	<0.01	1.90
C. Fields × depths	..	<0.01	1.90

B.

Dates of sampling.	Field 22	Field 31	Field 40	Mean for dates.
29-8-32	29.15	28.85	25.10	27.6
29-9-32	22.95	25.18	22.72	23.62
Mean for fields	26.05	27.02	23.89	..

C.

Depths of sampling.	Field 22	Field 31	Field 40	Mean for depths.
0″— 3″	22.95	25.18	22.72	23.62
9″—12″	22.02	22.67	20.07	21.58

On the first date, the surface moistures in Fields 22 and 31 were equal and greater than those in Field 40. A month later, in the first two fields, they were greater than the moistures in lower depths, but not so in Field 40. The moistures in both depths in Field 31 were much higher than those of the corresponding depths in Field 40; but they were higher than those in Field 22 only for the upper layer.

The black soil maintained a higher moisture level, especially at the surface, than the light-grey deep soil, while the surface-washed soil showed extreme fluctuation. Previous experience indicated that cotton yields were fairly high in Field 31, fluctuated very much in Field 22 and were low in Field 40.

In 1934, the moisture distribution was studied in other fields during wet spells, Nos. 8 and 20, liable to surface-wash and No. 6, well-drained and fertile, were selected. Observations for soil moisture were taken on 13th. August from 0-3 ins., and below in three-inch zones to 24 ins., on patches carrying poor growths and the adjacent areas around them with better growths of cotton and other crops in each field. They were confirmed for the upper zones from data taken a month later. The results are given below:—

TABLE 27.

A.

Mean percentage moisture in fresh samples, 1934.

Depths of sampling.	Good area.			Bad area.		
	Field 8	Field 20	Field 6	Field 8	Field 20	Field 6
0-3 inches ..	31.1	25.3	23.8	32.6	30.1	28.0
6-9 ,, ..	26.0	22.7	23.8	27.3	25.7	25.0

Significances : P.

B. Fields .. .. <0.01

C. Good v. bad area .. <0.01

D. Depths of sampling .. <0.01

B.

Field 8.	Field 20.	Field 6.	Significant diff.
29.2	25.9	25.1	2.5

C.

Good area.	Bad area.	Sig. diff.
28.1	25.4	2.04

D

0-3 inches	6-9 inches	Sig. diff.
28.5	25.1	2.04

E.

Area.	Depths in inches				Mean for good and bad areas.
	0-3	6-9	12-15	21-24	
Good ..	26.9	24.4	22.2	22.9	24.1
Bad ..	31.7	26.5	25.7	24.1	27.0
Mean for depths	29.3	25.5	23.9	23.5	....

Significances :

	P.	Sig. diff.
Good v. Bad area ..	<0.01	1.95
Depths of sampling ..	<0.01	2.20

Field 8 was in general moister than the others. The moisture was highest in the first 3 in. layer, next came 6-9 ins., and below one foot it remained at a constant level. Poor areas were moister at each depth in all the fields.

In all the soils examined precipitation does not seem to move quickly enough to the permanent moist zones below. Hence there always exists in the rainy season a downward gradient of diminishing moisture during wet spells and also in dry intervals, even when a thin surface layer of air-dry soil is formed. Thus the surface does not permit all the water to percolate; the excess flows over, causing severe surface-wash. The wet weather accumulations and the dry weather losses in the upper foot of the soil vary inversely with its fertility.

Observations on crop growths in the same patches were taken from time to time; the cotton crops were destroyed in both years by excessive rains. The following tables (28 and 29 A-D) include the observations on *jowar* (sorghum) for 1934 and on wheat for 1933.

TABLE 28.

Jowar crop—good and bad areas, 1934.

	Good area.	Bad area	P.	Sig. diff.	Between	r.
Grain in gms. per plant. ..	34.9	12.4	<0.05	19.49	Grain and Heights	.999

Jowar crop—good and bad areas, 1934.—*Contd.*

	Good area	Bad area	P	Sig. diff.	Between	r.
Heights in inches	76.2	53.1	<0.05	15.63	Grain and *kadbi*	.999
*Kadbi** in gms. per plant ..	72.3	20.2	<0.05	39.2	Heights and *kadbi*	.999

*Dry stems and leaves.

TABLE 29.

A.

Mean yield in gms. per plant : Wheat—1933.

Description.	Grain. Early matured.	Grain. Late matured.	Bhusa.* Early matured.	Bhusa.* Late matured.
Field 30				
Patch 1 ..	27.5	19.6	32.4	25.7
Patch 2 ..	20.8	12.8	25.9	16.4
Field 16				
Patch 1 ..	22.4	23.6	34.3	36.0
Field 18 ..				
Patch 1 ..	62.4	14.1	92.0	18.5
Patch 2 ..	34.0	16.0	54.5	27.5
Border ..	20.5	42.6	24.1	51.7

*Straw and chaff.

Significances:	P. Grain	P. Bhusa	Sig. diff. Grain	Sig. diff. Bhusa
Early vs. Late maturity ..	<0.05	<0.01	..	..
Fields	<0.05	<0.01	..	..
Patches	<0.05	<0.05	..	..
B. (Early vs. Late) × Fields ..	<0.01	<0.01	1.42	..
C. („) × Border vs. Patches ..	<0.01	<0.01	1.27	1.67
D. („) × Fields × Patches ..	>0.05	<0.05	..	3.05

B.

Type of maturity	Grain. Field 30	Grain. Field 16	Grain. Field 18	Grain. Mean for early & late	Bhusa. Field 30	Bhusa. Field 16	Bhusa. Field 18	Bhusa. Mean for early & late
Early ..	3.02	2.80	6.03	3.91	3.64	4.29	9.16	5.49
Late ..	2.03	2.95	1.89	2.68	2.63	4.50	2.89	3.66
Mean for Fields	2.52	2.88	3.95	..	3.14	4.39	6.01	..

C.

Type of maturity	Grain. Border	Grain. Patches	Bhusa. Border	Bhusa. Patches
Early	3.56	4.18	3.01	5.98
Late	5.33	2.15	6.46	3.13
Mean for border & patch	3.94	3.16	4.73	4.55

D.

Type of maturity.	Bhusa. Field 30 Patch 1.	Bhusa. Field 30 Patch 2.	Bhusa. Field 18. Patch 1.	Bhusa. Field 18. Patch 2.
Early ..	4.05	3.24	11.50	6.81
Late ..	3.21	2.05	2.31	3.44

The grain, heights and *kadbi* of jowar plants were greater in the good areas than in the bad. In all fields, portions of wheat crop were always observed to show delayed maturity in plants growing on patches inside the field which remained moister in the monsoon and also for those along the borders which were not so moist. It was found in 1933 that these late-maturing plants inside the field yielded less than early plants around them, but the late plants along the border yielded better than their neighbours and as well as the early plants inside the field. The early border-plants yielded more grain and as much *bhusa* as the late plants of the inside patches. It is thus evident that moist patches depress the yields of the succeeding *rabi* wheat and also delay its maturity.

Comparing the two groups of late plants, the lateness of the moist-patch plants seems to be due to their weakened vigour; that of the border-plants is not due to weakening but presumably to their ability to tap more water in the absence of competition, and in spite of their prosperous appearance their yield is only equal to that of the early plants inside the field.

It appears that vigour and health of crops (see page 13) are determined by the soil's capacity for free water movement in wet weather in the first foot, and for moisture retention in dry weather. This is why texture improvement by humus-supply shows superiority over other methods (page 22).

iv. Regional soil profiles—some comparisons.

The ability of Badnawar (Dhar) and Jaipur soils to grow a healthy crop of Cambodia cotton and the higher nitrifying activity in Jaipur soil compared with those of Indore suggested a detailed study of typical profiles (five feet deep) from each region.

The usual mechanical and chemical analyses were made, and hygroscopic moistures, maximum moisture-holding capacity, and available potash and phosphates were determined, the latter in inorganic and organic form. Some of the outstanding differences are noted below:

TABLE 30.

Differences in profile characters.

A.

Mechanical.

Percentage of	Jaipur profile.		Badnawar profile		Indore profile Field 31	
	1st zone 0′—6″	2nd zone 6″—15″	1st zone 0″—12″	2nd zone 12″—24″	1st zone 0—12″	2nd zone 12″—24″
Coarse sand ..	2.73	1.92	0.80	0.68	0.24	0.87
Clay ..	6.15	7.35	16.35	29.90	41.60	35.95
Co_2 ..	0.02	0.02	2.53	1.58	0.44	1.45

B.

Chemical

Availables in the first zone.

Soils	% total N	% available P_2O_5	% available P_2O_5 on total	% on available P_2O_5		Ratio, organic to inorganic P_2O_5
				Inorganic P_2O_5	Organic P_2O_5	
Jaipur ..	0.013	0.0075	19.95	16.00	84.00	5.25
Badnawar ..	0.041	0.0407	28.87	21.87	78.13	3.58
Indore F. 31 ..	0.036	0.0332	47.69	23.74	76.26	3.21

C.

Available potash in the first zone.

Soils	% available K_2O	% available K_2O on total K_2O
Jaipur	0.0248	22.15
Badnawar	0.0419	7.26
Indore	0.0287	5.51

D.

Ratios of available nutrients in the first zone.

Soils.	N to av. P_2O_5	N to av. K_2O	av. P_2O_5 to av. K_2O	Available P_2O_5 (inorg.) to K_2O	Available P_2O_5 (org.) to K_2O	N to inorg. av. P_2O_5	N to org. av. P_2O_5
Jaipur	1.73	0.52	0.30	0.05	0.25	11.06	2.06
Badnawar	1.01	0.98	0.97	0.21	0.76	4.61	1.29
Indore	1.08	1.25	1.16	0.28	0.88	4.56	1.42

The proportion of coarser fraction was greater and that of clay less in the top zone than below in Jaipur and Badnawar soils, and vice-versa in Indore soils.

Carbonates gradually increased with depth in Jaipur. In Badnawar soil the percentage was high in the top zone and low in the Indore soil; in each it then alternated in successive lower layers.

The percentage of available phosphates on total was least in the Jaipur surface zone and greatest in that of Indore. Always more than 75% of the available phosphate was in the organic form and this was highest in the surface horizon of the Jaipur profile and lowest in Indore; both its absolute percentage and its ratio to the inorganic form were highest in Jaipur and lowest in Indore soils.

Similarly the available proportion of total potash was highest in Jaipur and lowest in Indore soils.

In Jaipur and Badnawar soils much more potash was available in proportion to nitrogen than in Indore soils. In the same way, in proportion to phosphates, both organic and inorganic, the largest amount of potash was available in Jaipur soils and least in Indore soils.

These differences seem to be interesting in the light of the results discussed in the cotton wilt section of this report (9) (a) and those on nutrition (9) (b), (c) and (d).

10. Crops other than cotton.

(a) Plant Breeding.—

Study of the crops of Central India and Rajputana immediately reveals the great importance of local adaptation. This is shown in the frequent failure of varieties in trials carried out outside their native tracts, and by the failure of types brought into the Institute's plant breeding plots from outside districts even though these may apparently belong to the same tract. It follows that if the Institute's plant breeding work is to be of value to the whole of the area served, it must be carried out in such a way that advantage is taken of the selective action of local environments. Methods of selection are therefore being studied with a view to devising a technique simple enough and rapid enough to be carried out by busy local officers with the assistance of one or two advisory visits per annum from members of the Institute's staff. This work has been started both at the Institute and at outstation on *jowar* (sorghum), *bajra* (millet), *tur* (pigeon pea), *tilli* (sesamum), niger, groundnut, wheat, barley, linseed and gram. The past years' results with the *kharif* crops have already been analysed and are very encouraging.

(b) Botanical :—

The developmental study of bread and *durum* wheats was carried out in the *rabi* season, and the data await analysis. It is not expected that any further experimental work will be required.

(c) Cytological :—

The development of more profitable lines of work has made necessary the postponement of work on the chromosome number of gram. Chromosome numbers of Indian and Moroccan linseeds were determined in root-tip material and were found to be the same in both types.

(d) Fodder Plants.—

A list of the natural fodder plants occuring in the neighbourhood of the Institute has been compiled, and is available for the assistance of those engaged in agronomic work on fodder improvement.

(e) **Tobacco**:—

It is now definite that all types of tobacco, including cigarette type can be grown satisfactorily on any soil in Malwa and in Rajputana and Bundelkhand. The possibility of curing yellow leaf under grass is finally established, and leaf of good quality can be thus produced. Local methods of curing *desi* tobacco have been improved to ensure greater uniformity and quality. A large-scale experiment to find out the economics of the culture of tobacco with flue-curing has been undertaken this year in co-operation with the Dhar Durbar, whose enterprise in this matter is much to be commended. The production and grading of the seed have been systematized. The raising of seedlings and cultivation have been improved and made simple. It has been found possible by ratooning to make up for the loss of the crop by frost wherever one or two irrigations can be given. It is also considered that tobacco cultivation can be made more profitable by systematic ratooning of a normal crop.

(f) **Rice.**—

Large-scale trials in several parts of Malwa have been undertaken as a preliminary to final recommendation for distribution. It has been found possible to grow a profitable crop of wheat or tobacco following, in the same year, rice grown by the Indore method in which no irrigation or puddling is given. It is remarkably responsible to manures and very high yields have again been obtained of five varieties with superior scented grain.

(g) **Sugar beet.**—

Closer spacing increases yields. The crop responds well to artificial manures. The ease and practicability of drying a crop on a large scale has now been proved. The hand-slicer designed at Indore has proved very satisfactory.

(h) **Sugarcane.**—

Co. 290 is decidedly the best variety of those so far tried, for all districts in Central India. The cane-sorghum crosses and some other early varieties imported from Coimbatore have matured in seven months. It seems possible to extend the season for harvesting sugarcane by growing a judicious selection of early varieties to supplement Co. 290. The cultivation of sugarcane has been further improved and made simpler and cheaper. Replicated experiments on manuring and irrigations, ratooning and associated growth of varieties are being carried out.

(j) **Lucerne.**—

It has been found possible to reduce the cost of seed and irrigation by drill-sowing and implement culture. Good viable seed has now been produced locally.

(k) **Preliminary small growth tests on various crops :—**

Kudzu vine, *kolingi*, tepary beans and jute can be easily grown. Guinea grass, *khavi* grass, Wimmera rye grass and teff grass seem to stand even the hot weather drought just like other local grasses and appear again with the next rains. Soya beans are now being tested for large-scale cultivation in Malwa and Bundelkhand—they seem to suit the latter area peculiarly well.

11. Statistics and field-trial technique.

Four papers on the technique of field trials, chiefly with reference to cotton, have been written and submitted for publication. Studies of sampling technique for the estimation of yield and of morphological characters are in progress. The work of testing named varieties of the chief crops of Central India and Rajputana is almost finished, and a report of the results obtained and the recommendations made is in preparation. The problem of simplifying field trials to improve their suitability for out-stations where detailed scientific control is not possible continues to receive attention.

In the season under review the randomised-block technique was successfully applied to the problem of testing progeny rows in plant-breeding work. Problems arising out of the necessity of using very small plots, the very different amounts of seed available in different progenies, and the effect of dispensing with plot margins are being studied, and the first results will be ready for publication shortly.

12. Miscellaneous.

(a) Agronomic survey.

A great deal of information has been collected about the present status of farm crops in relation to their environment and the local economy in Central India and Rajputana. Revenue department records—a mine of information not yet much exploited in agricultural science—have been freely drawn upon, thanks to the willing co-operation of the State Officers concerned.

(b) Soil erosion.

Experience has shown that the system on which the Institute Farm was laid out—rectangular fields graded to a uniform gentle slope of limited length and served with border drains—does not prevent serious erosion in the rains. The method of contour bunding, utilizing suitable perennial plants in strips to arrest water-borne silt is being tried extensively to adapt it to local conditions. A number of plants have been tested for this purpose.

(c) **Eradication of *kans* and other weeds:—**

It was noticed in the making of rain-watered compost that all vegetation under the heaps of decomposing wastes was killed after being covered for a month or less. Small-scale field trials with covers of green grass or sunn hemp showed the same effect and an attempt is now being made to join the function of weed killing to that of green manuring; if successful this promises to be the cheapest means of weed control, costing far less than mechanical and chemical methods used.

(d) **Dry farming and humus supply in arid regions.**

Following up the results of qualitative tests on the Jaipur State Farm, replicated experiments are now laid down to find the best way of retaining the deficient rainfall so as to make possible cotton and other such crops by ensuring the necessary water-balance in the crop up to maturity.

(e) **The use of heated soil.—**

The efficacy of heated soil is being tested to enable satisfactory growth of exotic and *desi* cotton varieties which are at present difficult to grow in local black soils. A replicated experiment is also being carried out to compare the efficacy on American and *desi* cottons of heated soil with ammonium sulphate when applied in combination with phosphatic compost.

A simple technique has been devised to make heated soil cheaply in the field with the help of available crop residues.

(f) **Poisoned bait for white ants etc.**

The composition of the baits has been improved to make them more attractive and efficacious. Field trials are in progress to determine utility and cost.

13. Compost manufacture.

(a) **Farm refuse.—**

The rain-watered process of compost-making has been applied to the utilization of cane trash and an account published which is being reprinted as Institute Bulletin No. 3. Work has been started to devise a technique for composting cane trash during the dry weather and also for utilization of molasses. Another modification recently devised enables residues rich in material of the softer type to be composted without the use of cattle dung and composting is being introduced with entire success in Military stables in the Holkar State.

The method of charring and crushing bones for use as manure, either alone or in the form of compost has been systematized,

(b) **Habitation wastes.**—

It has been found possible to reduce by about 50% the breeding of fly larvae on the surface and sides of decomposing heaps even in wet weather by spraying 1% copper sulphate solution after charging and after the first turn. About 2½ lbs. of copper sulphate per foot-length, of the charge are required. This reduction is only obtained if the technique for charging and first turn is carefully followed. The addition of such material does not seem to affect the quality of the compost. The extra expenditure and manipulation involved appear to be of doubtful utility in practice because in any case such larvae are destroyed after the first turn if the process is properly carried out.

Widespread interest has been displayed in the process by Public Health officers, municipalities and others, both in India and abroad ; enquiries are constantly being received, over 500 copies of the Bulletin (No. 1) describing it have been sold and the first edition of 1500 copies is now exhausted.

(c) **Use of compost.**

A method has been devised and is being tried on a field scale to raise the fertility of *barani* (*mal*) lands more nearly to the level of that of garden lands (*adhan*) by applying manure or compost uniformly in the deeper layers in addition to surface dressings.

14. Publications.

The following papers have been published or submitted for publication :—

"The health and vigour of the cotton plant in relation to its environment"—Report 2nd. Conf. on Cotton Growing Problems, July 1934, Empire Cotton Growing Corporation.

"Silage making in mud-walled towers"—G. C. Tambe and Y. D. Wad ; Empire Cotton Growing Review, XI, 1934, No. 4.

"Humus manufacture from cane trash"—G. C. Tambe and Yeshwant D. Wad ; International Sugar Journal XXXVII 1935, pp. 260-263.

"Some observations on the inheritance of form and size in Asiatic cottons;" By J. B. Hutchinson (To be read at the VIth. International Botanical Congress, Amsterdam, September, 1935).

"The classification of Gossypium with special reference to the cottons of the Old World", by J. B. Hutchinson and R. L. M. Ghose.

"Studies in the technique of field experiments" by J. B. Hutchinson and V. G. Panse.

(I) "Size, shape and arrangement of plots in cotton trials."

(II) 'Sampling for staple length determination in cotton trials, with a note on the standard error of estimates of ginning percentage.

(III) "An application of the method of covariance to selection of disease resistance in cotton."

(IV) "A study of margin effect in variety trials with cotton and wheat."

"A note on the inheritance of sterility in cotton" by J. B. Hutchinson and P. D. Gadkari.

"Nitrogen balance in black cotton soils in the Malwa Plateau—II" by Y. D. Wad and R. K. Aurangabadkar.

Institute leaflets issued or revised during the year :—

No. 5—"Improved method of gur manufacture" (English and Hindi, illustrated).

No. 7—"Lucerne cultivation " (English & Hindi).

No. 9—"Cultivation of cotton in the Gang Canal Colony." (Urdu.)

No. 10—"The preparation of bone -char manure" (Eng.)

No. 2—"The making of rain-watered compost manure from farm wastes" (English & Hindi) Revised June 1935, with one illustration.

The following papers were read at the 1935 Session of the Indian Science Congress, Calcutta :—

"Influences dominating cotton yields in Monsoon Areas—I", by Kubersingh and Y. D. Wad.

"Nitrogen balance in black cotton soils in the Malwa Plateau—III' by Y. D. Wad and B. K. Aurangabadkar.

"Provision of succulent fodder for work-cattle in Central India", By G. C. Tambe, Chironjilal Nagar and T. Krishnamoorthy.

"Agronomic adjustments of the cotton crop in Gang Canal Colony, Bikaner State," by Shamsher Singh and Y. D. Wad.

THE WORKING OF THE FARM.

15. Experimental work.

(a) Nature of the season.

As usual the monsoon broke in the last week of June and the sowing started on the 26th. On the 27th and the 29th there was a heavy downpour. The fall up to the end of July was 18,9 inches—more than half

the yearly average for Indore. The next month was equally wet throughout, the total having gone up to 40.07 inches. In September 16 inches of rain fell with a couple of breaks. In October there was no rain. November 5th recorded a fall of 1.34 inches. In January a cold wave lasted for four days. The temperatures recorded were as follows :—

1935 January	12	..	50°F
,,	13	..	40°F
,,	14	..	34°F
,,	15	..	29°F
,,	16	..	29.5°F
,,	17	..	31.5°F
,,	18	..	31.5°F
,,	19	..	37.5°F

(b) Field Trials.—

The following experiments were conducted on the Farm :—

Humus supply :

(1) Incorporation of organic matter in the soil.

(2) Effect on wheat, of green manuring with *sann* (*crotalaria juncea.*) at different stages.

(3) Improvement of water-logged soils for *rabi* crops.

Soil improvement :

(1) Improvement by the application of lightly heated soil.

(2) Control of soil erosion by contour line sowing and the use of arrester crops.

Soil texture & crop growth :

(1) Winter cultivation of crops (1932, 1933, 1934, 1935).

(2) Estimation of the relative importance of weeding and interculture (1934, 1935).

(3) Comparison of the efficiency of different implements of interculture (1933, 1934, 1935).

Rotation :—

(1) Rotation of crops (1932, 1933, 1934, 1935).

(2) Influence of previous crop on cotton.

Associated growth of crops :

(1) Association of cotton with soya beans and cowpeas.

(2) Spacing test on *tur* and its association with cowpeas,

Weed eradication.—

(1) Eradication of *kans* by chemical means.

Treatment of seed:

(1) Trial of Agrosan "G" against *jowar* smut.

Multiplication of seed :

(1) Soya beans, 32 varieties in *kharif*.

(2) Soya beans, 6 varieties, in *rabi*.

(3) Paddy 7 varieties, (followed by wheat).

Paddy variety.	Date of harvest.	Paddy yield, mds. p. ac.	Wheat yield, mds. p. ac.
Shahjahanpur 23	2-10-34	12.0	8.68
,, ...	,,	15.7	9.85
Shahjahanpur 1	2.10-34	9.3	9.00
,, ...	,,	10.6	12.40
Jhona	,,	12.5	10.30
,, ...	,,	4.3	6.70
,, ...	,,	29.3	6.70
Datia	15-10-34	16.0	4.60
,, ...	,,	15.4	4.15
,, ...	,,	11.14	4.27
Bhatta Gurmatia	29-10-34	16.3	4.80
,, ,, ...	,,	14.4	4.50
,, ,, ...	,,	14.9	4.66
Mushkan	8-10-34	12.6	10.00
,, ...	,,	17.2	5.40
Pahan	10-10-34	9.0	5.45
,, ...	,,	4.2	7.60

Paddy not irrigated, wheat—2 irrigations.

Small growths :

(1) Oats for fodder.

(2) *Bajilla* for fodder (*vicia faba*).

Sugarcane :

(1) Multiplication of promising acclimatised Coimbatore varieties and also sorghum crosses.
(2) Varietal trial on S. 48, Co. 210, Co. 213, Co. 281, and Co. 290.
(3) Agronomy trial on S. 48.

Lucerne :

(1) Inoculation of seed
(2) Manurial trials
(3) Agronomy trial

Sugar beet :

(1) Trials in different soils under dry and irrigated conditions.

Pasture Studies :

(1) Response of grasses to various manures.

Compost :

(1) Preparation of phosphatic compost.
(2) Composting cane trash.
(3) Composting cowdung alone.

16. Crops and Yields :

Dry crops :	Yields in mds. per acre.	
	Max.	Min.
Cotton	3.6	1.4
Jowar	9.7	0.4
Tur	5.4	0.3
Groundnuts :		
Gangapuri	13.1	1.1
Akola 10	5.5	0.9
Wheat (Malvi)	9.5	2.0
Gram ,,	9.0	1.0
Linseed	4.5	3.7

Irrigated crops :

Paddy (*Mushkan*)		29.0	12.6	Plot size 50×20 sq. ft.
Sugarcane	Co210	534-6 mds.		
	Co313	464.7		
	Co281	445.0		
	Co290	610.9		
	S. 48	318.7		

Lucerne agronomical

Year.	Season	Cuttings	Plot yield in lbs.	Total per acre in lbs.
1932-3 ..	Winter	2	5480	
	Summer	6	27876	
	Monsoon	3	7180	
				45040
1933-4 ..	Winter	4	10133	
	Summer	5	10053	
	Monsoon	2	3443	
				26250

Lucerne-manurial :

Year	Season	Cuttings	Plot yield in lbs.	Total per acre in lbs.
1932-3 ..	Winter	1	5307	
	Summer	5	23513	
	Monsoon	3	4129	
				47070
1933-4 ..	Winter	4	9189	
	Summer	5	13858	
	Monsoon	2	4583	
				39470

Peas (green pods) .. 8.8 mds.

Seed 2.6 ,,

The calculated gross returns from the Farm amount to Rs. 5,000. The wet weather coupled with the cold wave reduced this figure seriously.

17. General.

(a) **Live Stock :** There are fifteen pairs of bullocks in all, including six purchased to replace those that through old age became unserviceable or died. The new pairs are of average size usually found with cultivators.

460 cartloads of compost were prepared from the available farm-wastes and 32 cartloads of night-soil compost from the residential block (population about 100).

1145 mds. of silage from grass and legumes was made. This provided an excellent succulent fodder for the hot weather.

(b) **Workshop :** This section continued to render useful service in the same directions as reported last year. The sugar beet slicer devised in the previous year was further improved upon.

A portion of the fence line was repaired and the wood-work of the buildings repainted.

(c) **Irrigation :** A Persian wheel was installed, in place of the Boulton Elevator worked by engine power, for purposes of demonstration and economy.

One of the wells capable of commanding a fair area had been out of use on account of its dilapidated condition. The debris was removed and the well cleaned and repaired. Now there is one good well and two of moderate capacity in the 'C' block of the farm.

(d) **Trading Section :** This section was very busy and considerably more sales than those of the last year were effected in implements, tools and seeds. The demand for improved seeds exceeded the supply.

(e) **Training of students and help to cultivators :** In all about 120 students from the following States were given training in either practical agriculture or composting farm and habitation wastes :—

Alwar	Bharatpur	Bundi
Chhatarpur	Hyderabad (Dn.)	Indore
Jaora	Jodhpur	Nowgong
Rewa	Rutlam	Tonk
Udaipur		

These students can be classed as under :—

Normal School Boys	75
,, ,, Teachers	3
State officials connected with agriculture	12
Municipal officials and menials ..	10
Army officers; Holkar State	6
Union Theological Seminary students for rural propaganda	15

Trained ploughmen were deputed to various States to teach compost making and *gur* making by the improved method. Many cultivators came directly for information and help, showing their confidence in the work.

PROPAGANDA AND EXTENSION WORK IN STATES.

18. Visits to States.

During the year under report, the Agricultural Adviser made sixteen visits to States, the Extension Officer, nineteen, the Geneticist & Botanist seven, the Chemist & Agronomist eleven, and other staff thirteen.

19. Instructional and training facilities :

No fixed lecture courses are provided but practical training is given at the request of the Darbars to members of their Revenue and Agricultural staffs and selected cultivators, the programme of instruction being varied in its items to suit individual cases. No fees are charged and free accommodation is usually provided in the Institute's Visitor's Quarters.

Special lectures and demonstrations were arranged for repeated visits from the Kumars of the Daly College (for sons of the Ruling Princes and their relatives) and from the students of the Canada Mission's Theological Seminary, their Rasalpura Vocational School and the Holkar State's Normal School for training rural teachers. Such contact with those who will later be able to encourage agricultural improvement is a matter of great importance.

With the co-operation of the Indore Residency Area authorities, training in the sanitary disposal of habitation wastes by the Institute's composting process has been given to municipal staffs from seven member-States, Hyderabad (Deccan) and Chhatarpur States and Nowgong Cantonment, a fee being charged to non-members. Officers from five units of the Holkar State Army were also trained in the process and in that for composting stable refuse. The Secunderabad Cantonment requisitioned the services of a trained assistant for a month to make certain adjustments in the process desirable under the local conditions and to help in the laying out of new disposal grounds under the system.

Lectures and demonstrations were given by the Extension Officer in district tours in eight States. To large village audiences he explained the advantages of growing good crop varieties, of increasing their manure supply by making rain-watered compost from waste, of making grass, *juar* or *bajra* silage for their cattle, using mud-walled towers where pits become water-logged, the practical possibility of improving their cattle by castrating "scrub" bulls, the lower cost of making better quality *gur* by the McGlashan furnace and a variety of other improvements within the capacity of ordinary cultivators. The services of ploughman trained in building the McGlashan furnace and in *gur* making were placed at the disposal of the Darbars and were freely used.

Assistance was also given by the Extension Officer in organizing demonstrations at twelve agricultural shows and cattle fairs in eight States. Illustrative exhibits were provided, lectures given and cinematograph films shown of agricultural and rural uplift subjects accompanied by running commentaries.

At a public meeting in Jaipur presided over by Lt. Col. Sir H. Beauchamp St. John, K. C. I. E., C.B.E., Vice-President, Council of State, the Extension Officer explained the work and objects of the Institute to a large audience of landowners, State officials and cultivators ; cinematograph films were also shown.

Acknowledgment is due to the Indian Central Cotton Committee and the Central Publicity Officer, Railway Board for the free loan of films.

STAFF AND RESEARCH STUDENTS OF THE INSTITUTE OF PLANT INDUSTRY AS ON JUNE 30th, 1934.

Administrative & Clerical :—

Director & Agricultural Adviser to States in Central India & Rajputana	F. Keith Jackson, N.D.A. (Hons.) Dip. Agri. (Cantab.)
Personal Assistant ..	.. A. N. Srivastava, M.Sc.,
Head Clerk & Accountant	.. G. M. Nadkarni.
2nd Clerk	.. Mohiuddin Khan.
3rd Clerk	.. S. M. Ajmi.
4th Clerk	.. S. M. Azim.
5th Clerk	.. V. R. Shirsath.
Artist	.. S. J. Oncar.
Librarian	.. Bashir Husain Khan.

Botanical :—

Geneticist & Botanist ..	.. J. B. Hutchinson M.A. (Cantab).
Senior Botanical Assistant	.. R. L. M. Ghose, M.Sc.,
Plant Breeding Assistant	.. Kuber Singh, B. Ag.
Botanical Assistant ..	.. Vacant.
Statistical Assistant ..	.. V. G. Panse, B.Sc.,
Genetical Assistant ..	.. Bholanath, M.Sc.,
Computor	.. S. A. Khargonkar.
Fieldman	.. E. L. Rajanna.
Research Student ..	.. G. K. Govande M. Sc.,*
" " ..	.. M. A. Ansari M.Sc.,*
" " ..	.. P. D. Gadkari M.Sc.,*
" " ..	.. M. P. Singh M.Sc.,†
" "	.. B. S. Kochrekar, B.Ag.,†

Chemistry & Agronomy :—

Chemist & Agronomist ..	.. Y. D. Wad, M.A., M.Sc., A.I.I.Sc.,

Laboratory Assistant ..	.. L. N. Desai, B.Sc.,
,, ,, ..	.. G. T. Shahane.
Laboratory Assistant (temporary)	.. V. V. Dravid, B.Sc.,
,, ,, (,,)	.. S. J. Ghose, B.Sc.,
,, ,, (,,)	.. G. K. Sant, B.Sc.,
,, ,, (,,)	P. M. Kulkarni, B.Sc.,
,, ,, (,,)	.. B. Goswami, B.Sc.,
,, ,, (,,)	.. R. S. Gharpure, B.Sc.,
Research Assistant (,,)	.. I. Madhusudan Rao, M.A., M.Sc.,
,, ,, (,,)	.. Chironjilal Nagar, B.Sc.,
,, ,, (,,)	.. V. N. Bhargave, B.Sc.,
Research Student ..	.. R. K. Aurangabadkar, M.Sc.,*
,, ,, ..	.. S. C. Chakarvarty, M.Sc.,*
,, ,, ..	.. K. N. Ambegaonkar, M.Sc.,*
,, ,, ..	.. S. B. Mogre, M.Sc.,*

Propaganda & Extension Work:—

Extension Officer ..	.. M. L. Saksena, L. Ag.,

Farm Executive:—

Farm Superintendent ..	.. G. C. Tambe, B.Ag.,
Assistant Farm Superintendent	.. S. C. Talesara, B.Ag.,
Junior Farm Assistant.	.. G. C. Phadke, L.Ag. (on deputation to Bharatpur State as Agricultural Officer)
,, ,, ,, ..	.. N. S. Apte, B.Ag., (actg.)
,, ,, ,, ..	.. K. M. Simlote, B.Ag.,
Fieldman ..	.. Nihalsingh.
,, ...	.. V. R. Sathe.
,, ...	.. G. M. Nigudkar
Storekeeper	.. V. S. Dravid.

* Institute of Plant Industry Studentship.

† Voluntary research worker.